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FINAL REPORT

H-189()/GR

CONTRACT NO. DA 36-039 SC-87244

**U.S. ARMY SIGNAL RESEARCH AND DEVELOPMENT LABORATORY
FORT MONMOUTH, NEW JERSEY**

**ELECTRO-VOICE, INC.
BUCHANAN, MICHIGAN**

SECURITY CLASSIFICATION: None

TITLE OF DEVELOPMENT: H-189()/GR

REPORT NUMBER: Report Number 1

SIGNAL CORPS CONTRACT NUMBER: DA 36-039 SC-87244

SIGNAL CORPS TECHNICAL REQUIREMENT NUMBER: SCL-4195

OBJECT OF DEVELOPMENT: To develop a miniature handset, incorporating dynamic microphone and earphone elements, to be used with military man-pack radio equipment.

REPORT PREPARED BY: Robert C. Ramsey

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SECTION I

PURPOSE

The purpose of this contract was to develop a miniature handset incorporating dynamic earphones and microphones and meeting the requirements of Signal Corps Technical Requirement SCL-4195.

The development of the handset was accomplished in three phases:

- (a) Design and fabrication of three mock-up models.
- (b) Development, construction and test of six engineering models.
- (c) Production of twenty service test models.

SECTION II

ABSTRACT

This report describes the design, development and testing of the H-189()/GR.

The H-189()/GR is a miniature handset incorporating blast-proof, shock-proof, watertight dynamic earphones and microphones. This handset is to be used with military man-pack radio equipment, in particular, the VRC-12 radio equipment.

Design requirements for the handset were detailed in Signal Corps Technical Requirement SCL-4195.

SECTION III

CONFERENCES

DATE	PERSONNEL	PLACE	RESUME
July 6, 1961	EV: W. Beaverson R. Ramsey H. Mosier Sig Corps: C. O'Malley F. Vezzosi	Electro-Voice	Discussion of size, field use, component requirements.
July 27, 1961	EV: R. Ramsey H. Mosier Sig Corps: C. O'Malley F. Vezzosi	Signal Corps	Discussion of proposed mock-up models.
August 31, 1961	EV: H. Mosier Sig Corps: C. O'Malley F. Vezzosi	Signal Corps	Delivery of Item I.
November 1961	EV: W. Beaverson R. Ramsey H. Mosier Sig Corps: C. O'Malley F. Vezzosi	Electro-Voice	Discussion of cable and isolation problems. Examination of prototypes.
January 22, 1962	EV: R. Ramsey H. Mosier Sig Corps: C. O'Malley F. Vezzosi	Signal Corps	Delivery of Item II and testing of Item II.
March 5, 1962	EV: H. Mosier Sig Corps: C. O'Malley F. Vezzosi	Signal Corps	Delivery of modified handsets and start of test.

March 22, 1962

EV: R. Ramsey
H. Mosler
S. Hancher

Electro-Voice

Discussion of switch
life, small wire
sizes, and necessity
of stay cords.

June 13, 1962

EV: R. Ramsey
Sig Corps:
C. O'Malley
F. Vezzosi

Signal Corps

Discussion of tests
on the engineering
models and corrective
action required.

SECTION IV

FACTUAL DATA

1. INTRODUCTION.

Three separate phases in the development of the H-189()/GR handset were delineated in the contract:

- (a) Design of three mock-up models, each a distinct design approach.
- (b) Development, construction and test of six engineering models.
- (c) Construction of twenty service test models incorporating corrections resulting from deficiencies noted from the tests of the six engineering models.

The first step in the design of the handset was to establish the style and size of the unit. This was accomplished during the mock-up model phase of the contract.

Prior to the fabrication of the three mock-up models, experimental transducer elements were constructed to determine the required size of the microphone and earphone elements. During this period, the requirements of small size were discussed. SCL-4195 describes the H-189()/GR as a miniature handset and this description was interpreted to include the following size requirements: that the handset shall be no larger than a modified H-33 supplied by the contractor; and that it shall fit into the pocket of a field jacket. Also, at this time, the requirement of SCL-4195 for a noise-cancelling microphone was questioned and a decision made to change this requirement to a pressure microphone.

After a satisfactory mock-up model had been developed, work started on the development and construction of the six engineering test models. After the original shipment of these units, certain deficiencies were noted that required that additional test models be constructed. In particular, the pin terminals on the transducer elements were found to be fragile and the initial wiring of the handset did not work well with the associated radio equipment. Both of these details were changed in additional engineering models that were supplied. Most of the handset design details were worked out prior to the delivery of the engineering models. Important elements of the design included: development of satisfactory microphone and earphone elements; development of the switch and cable; and design of the handset handle and caps.

As the result of tests performed on the engineering models, changes were made in the handset that were then incorporated in the twenty service test models. The twenty service test models were tested to determine design centers and conformance to the requirements of SCL-4195.

The H-189()/GR handset is shown in Figure 1.

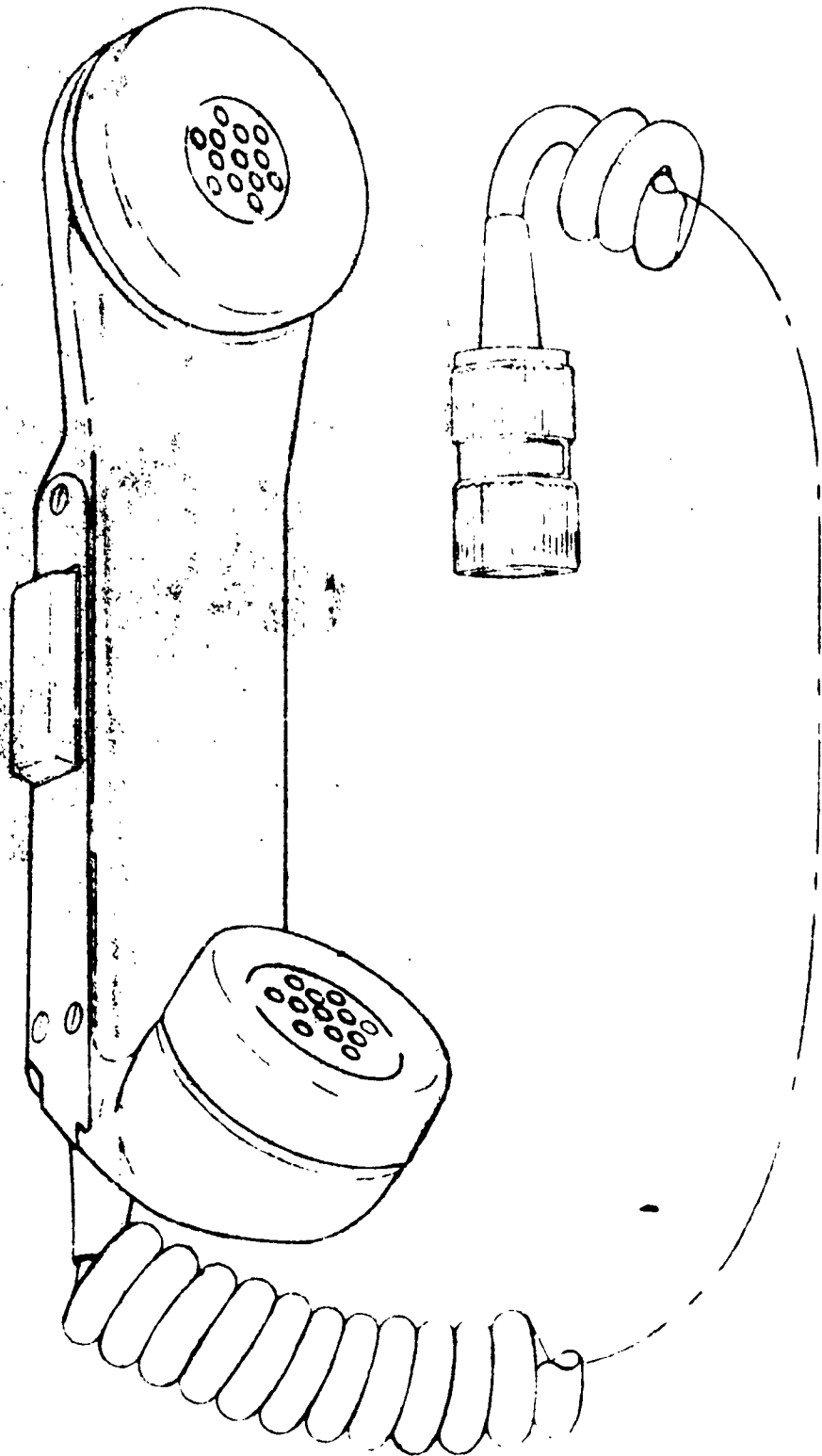


FIGURE 1.

2. MOCK-UP MODELS.

2.1 Requirements.

Considerations of use determined the following requirements for the size and shape of the handset:

- (a) Size no larger than a modified H-33 supplied by the contractor.
- (b) Small enough to fit in the pocket of a field jacket.
- (c) Hang-up bracket required.
- (d) Capable of being used when the user is wearing arctic gloves.
- (e) Must be capable of being used when the user is wearing a helmet liner.
- (f) Size of the earphone cap must be compatible with requirements of comfort when the cap is pressed against the ear.
- (g) Distance and angle between the microphone and earphone must be compatible with normal head dimensions.
- (h) Design of the handle must provide sufficient clearance between the hand and face of the user.

Signal Corps technical requirements for sensitivity determined the minimum size possible in the microphone and earphone element.

2.2 Development.

Early discussions were primarily centered on achieving the smallest possible size and meeting the requirement of fitting into the pocket of a field jacket. Several unusual designs utilizing folding and telescoping features were considered.

Three handset mock-up models were constructed each featuring a different style. These models are shown in Figures 2, 3 and 4. One model was constructed with a continuously molded handle and with screw-on covers for the microphone and earphone sections. This model represented the most desirable construction in the opinion of the contractor. A second model was constructed featuring a collapsible style in which the earphone section folded onto the microphone section to achieve a more compact unit for storage. However, the possibility of dirt, corrosion of contacts, and weakness of pivot combined to render this construction less desirable than the model with the one piece handle. Also, the physical size of the one piece model was such as to satisfactorily stow in the pocket of the smallest combat field jacket. Consequently, the need for a more compact model, by folding, was not prevalent. The third mock-up model was constructed with metal tubing which coupled the earphone and microphone sections to the switch and cable section. Also, the tubing housed the conductors for making electrical connections to the earphone and microphone. The contractor considered this construction to be the least desirable due to the use of metal which would naturally come in contact with the body.

Klein-Wassman Designers of Chicago, Illinois, were consulted on styling and human engineering considerations.

During examination of these mock-ups it was noted that a problem of clearance for the hand existed and that the fit of the unit to the face could be improved. Also, the diameter of the flat section of the earcap needed to be increased to improve the comfort of the cap resting against the ear. As a consequence of these observations an additional mock-up model was constructed. (Figure 2A)

Further changes in the shape were limited to an increase in the minimum dimension of the earphone section and a decreased taper on the outside diameter of the earphone and microphone cap.

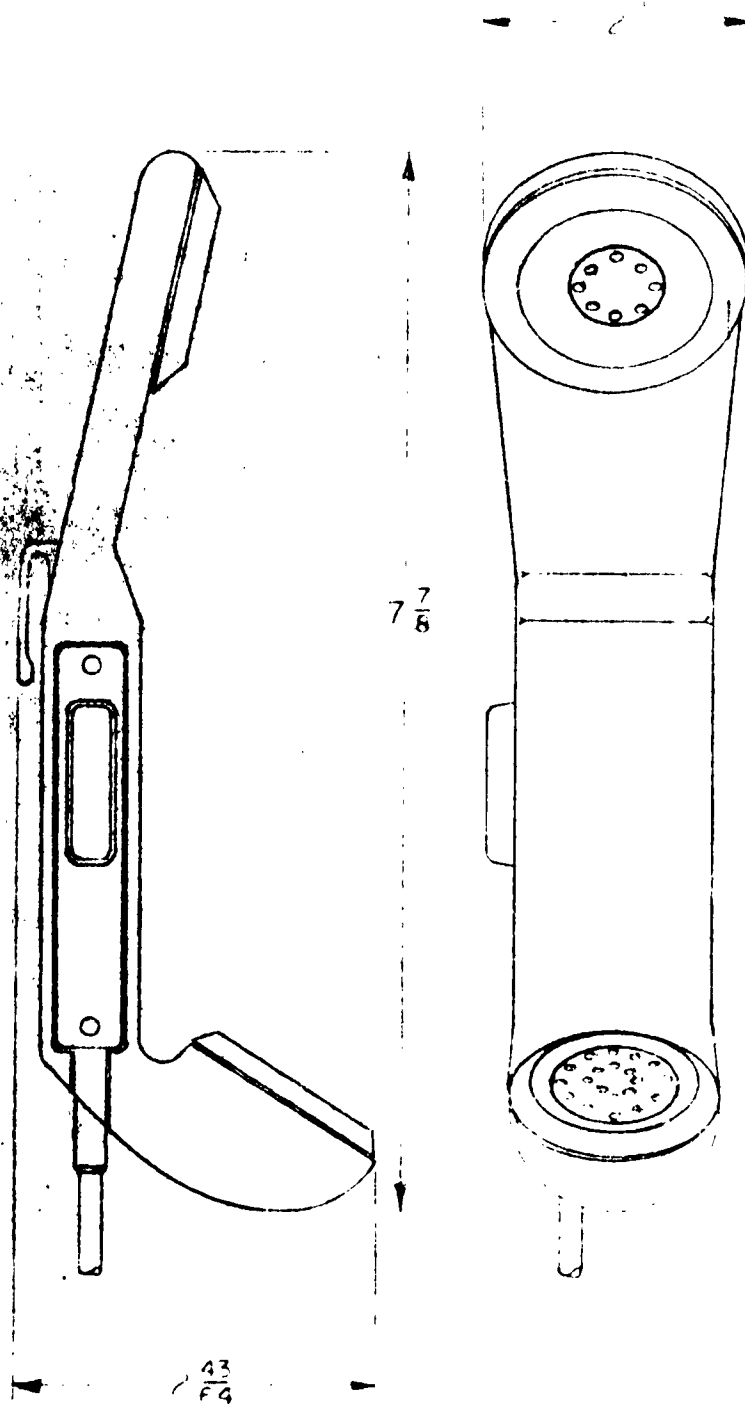


FIGURE 2.

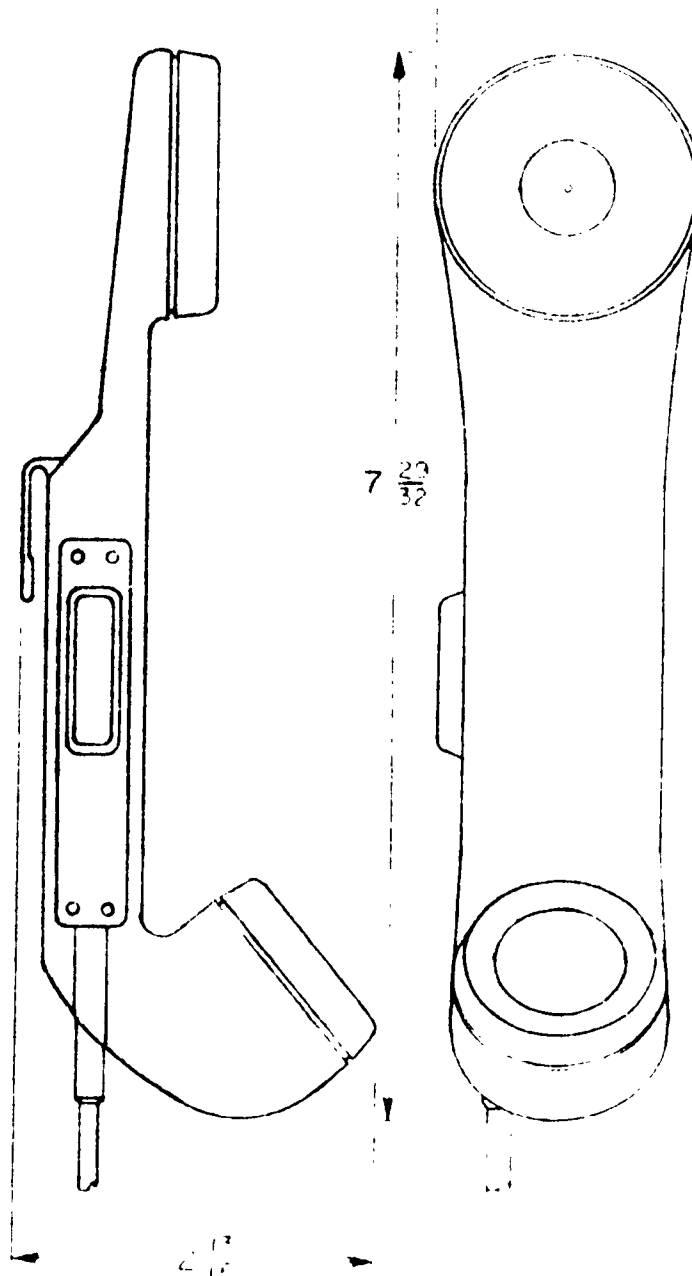


FIGURE 2A.

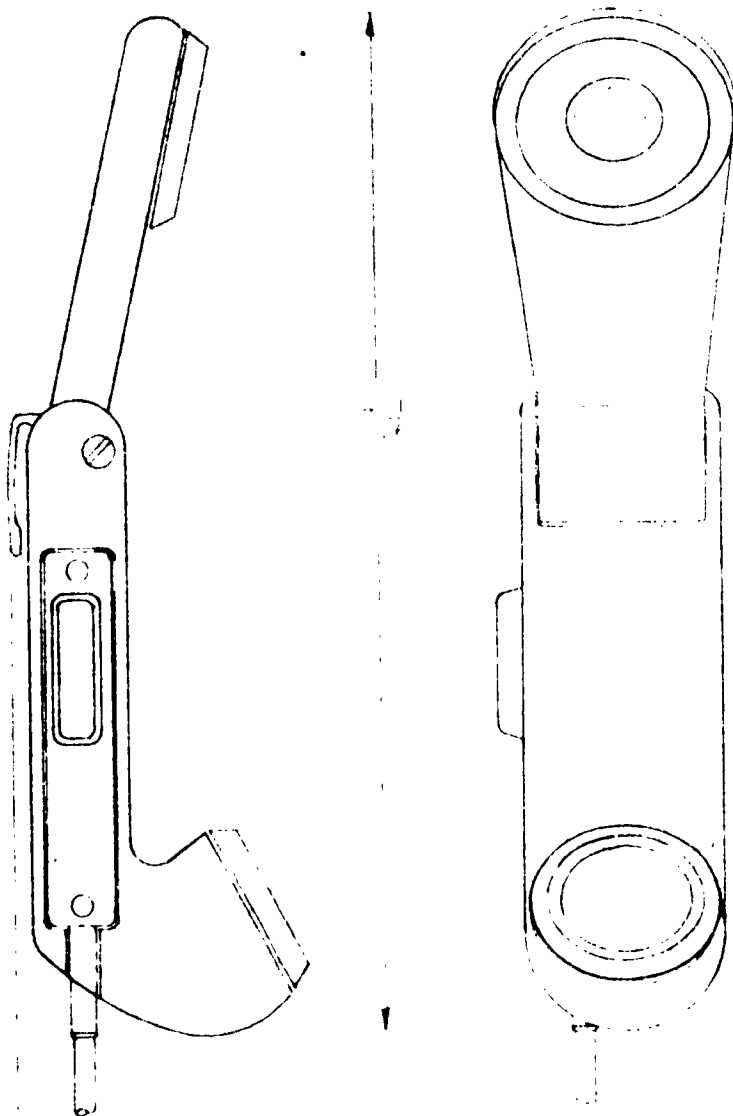


FIGURE 3.

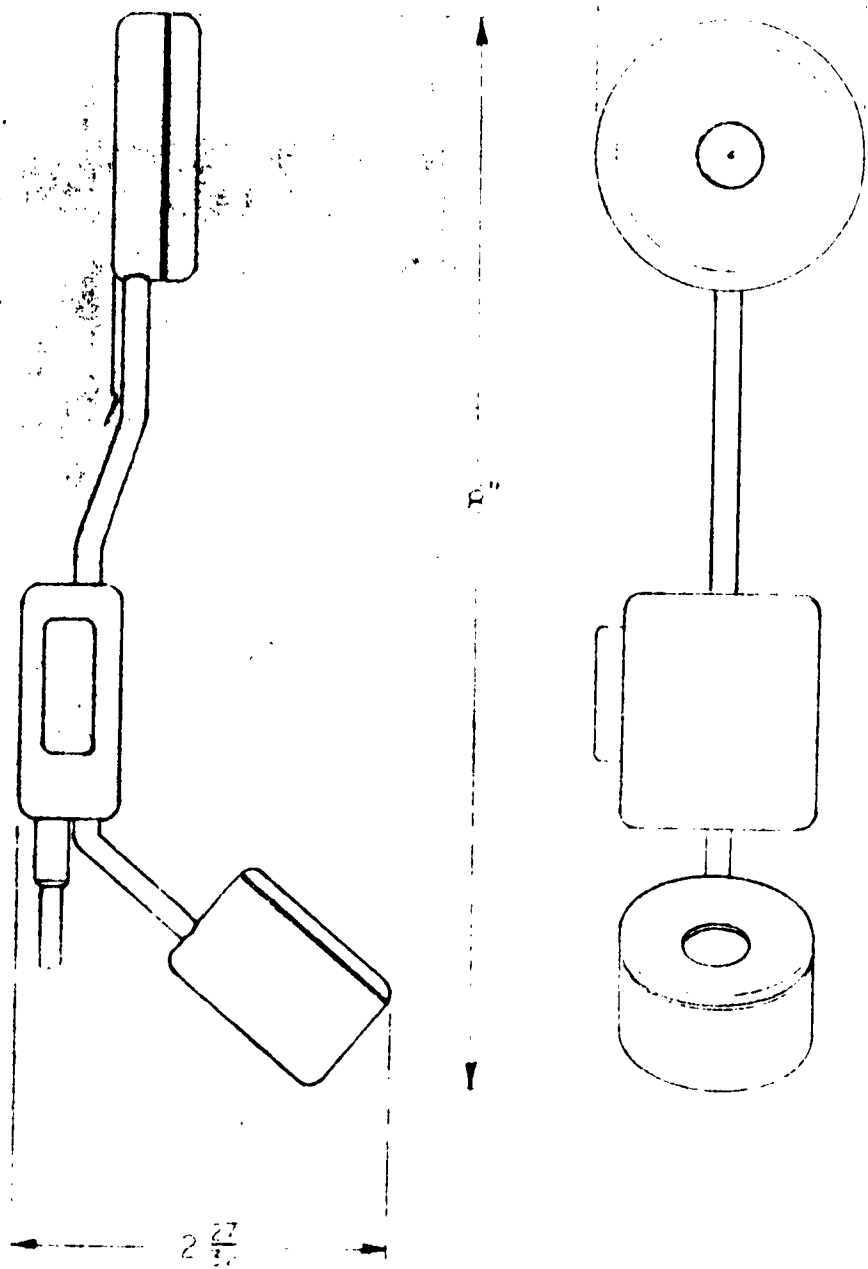


FIGURE 4.

3. ENGINEERING MODELS.

With the shape of the handset and primary design requirements determined during the design of the mock-up models, the development of the design details into a working handset remained. This phase was accomplished during the production of the six engineering test models.

3.1 Handset Handle and Caps.

Because of the requirement for small size and the service requirement for a handset capable of being dropped six feet onto a concrete floor, a material with very high impact strength was required for the handset handle and caps. This high impact strength must be combined with sufficient flexural strength and hardness so that large deformations would not occur during normal stresses. This combination was available in a polycarbonate thermoplastic (G.E.'s Lexan). In addition to having very high impact strength, high flexural strength, and a Rockwell hardness of R118, this material retains good impact strength at low temperature and will not maintain combustion.

Because of the unique properties of this handset material, self tapping screws were specified to hold the switch plate. Tests showed that with a 1/2 inch grip on the thread that the screw fractured before the screw threads could be stripped. Repeated use of the screw did not materially affect holding strength.

In the original design, screws were utilized to hold the caps to the handset. These screws were eliminated in favor of screw-on caps with the obvious advantages of simpler removal during repair and lower final assembly costs.

The immersion requirement in the design is met by making the switch cavity a sealed cavity and by making the microphone and earphone cavities sealed spaces vented by a breather capable of withstanding 3 feet of water. The breathers used were porous, sintered, stainless steel cylinders treated with silicone oil.

Connection between the switch cavity and the microphone and earphone cavities is achieved by inserting a wire form in the handset handle during molding. Electrical connection is provided at the end of these inserts by means of a "fuzz button" contact held in the wrapped end of the insert. The "fuzz button" is a Bell Telephone Laboratories development and is manufactured by Technical Wire Products, Inc. The button is an essentially continuous fine wire wound into a cylindrical shape. Electrical contact is made by pushing a pin into the button, with many small area, high pressure contact points established to give redundancy to the electrical contact. The advantages of this type of contact are: (a) that critical tolerances on the mating pins are not required; (b) that contact is maintained during vibration; (c) and, that contact is not susceptible to deterioration from dirt and non-conducting films.

A drawing of the handset handle is shown in Figure 5.

3.2 Switch.

3.2.1 Requirements.

The requirements for the switch as detailed in SCL-4195 include:

- (a) Bar actuated, positive detent switch with an actuating force of two to four pounds and a holding force of one-half of the operating pressure.

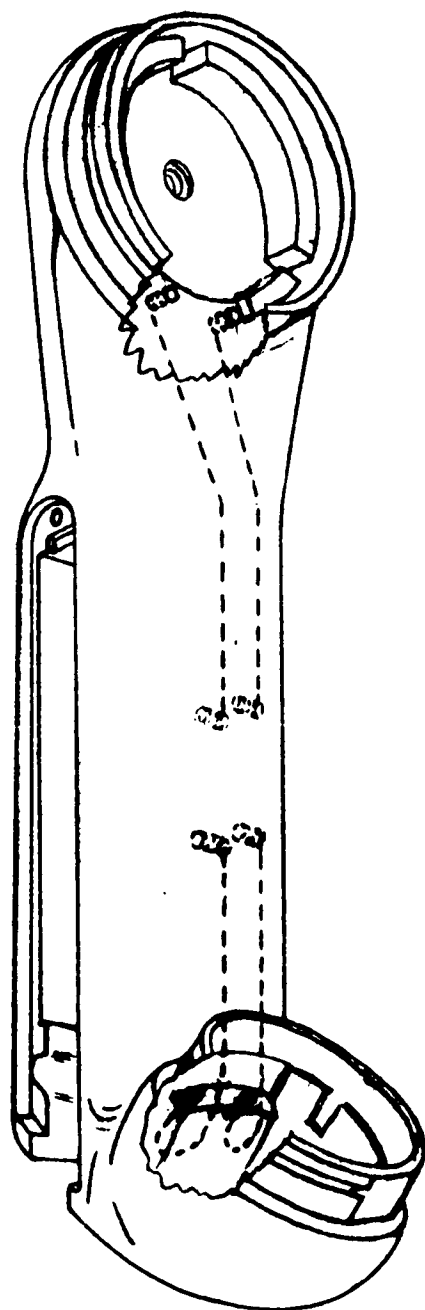


FIGURE 5.

- (b) Switch life of 500,000 cycles.
- (c) Maximum contact resistance of 0.2 ohms.
- (d) Microphone contacts shall make before the control contacts make; control contacts shall break before microphone contacts break.

In addition to these requirements, the design goals included low cost, ease of replacement and simplification of the wiring in the switch cavity.

3.2.2 Development.

The switch as designed contains two components: the electrical switch assembly and the mechanical actuator assembly.

The electrical switch component was designed by F & F Enterprises of Chicago and includes the following details:

- (a) Spring loaded pins to contact the "fuzz buttons" in the bottom of the switch cavity.
- (b) Solderless connectors that serve as terminations for the cable.
- (c) Provides all the necessary wiring and switching between the cable conductors and the insert terminations, thus eliminating the need for loose wiring in the switch cavity.

The mechanical actuator assembly includes the bar and its support and a heat treated spring that provides the detent action and determines the actuating and return forces. A drawing of the switch is shown in Figure 6.

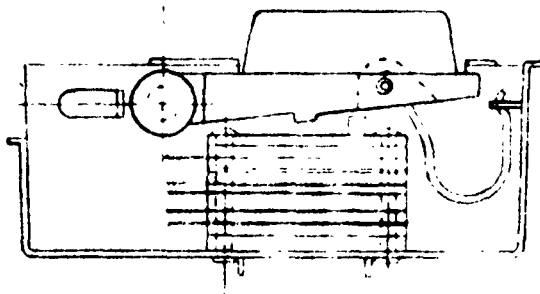


FIGURE 6.

3.3 Cable and Connector.

3.3.1 Requirements.

The requirements, as outlined in SCL-4195, call for a four conductor, shielded, rubber jacketed, cable-terminated on one end in a U-182/U connector and providing 80 db isolation between the microphone and ear-phone conductors.

Because of the emphasis on small size, it was requested that an attempt be made to develop a small cable.

3.3.2 Development.

At the outset of the handset development, the possibility of utilizing a separate cable with the handset was considered. This would have allowed the use of varying lengths of cables with any handset and would have reduced the volume required for storage. However, this approach was rejected for the following reasons:

- (a) An additional set of connectors would have been required, thereby raising the unit cost.
- (b) The cable might be lost if it could be disconnected at both ends.

An attempt was made to miniaturize the cable. The contractor contacted several cable manufacturers concerning the possibility of developing a 3/4" maximum diameter cable using a 0.200 inch diameter conductor. Information received from the manufacturers contacted indicated that it would be impractical to miniaturize the cable. The principle reason given was that a relatively thick rubber body is required on the cable to provide adequate retraction of the cable.

A further attempt to reduce size by utilizing a three conductor, one shielded, cable failed because electrical noise in the control current generated electrical noise in the microphone circuit. The wiring of the handset, using a three conductor shielded cable, is shown in Figure 7. Since the control circuit was common to the microphone circuit in the shield, noise variations in the control current generated a noise voltage in series with the microphone output. This noise was of sufficient magnitude to require the use of a four conductor cable in which the control circuit is independent of the microphone circuit.

The wiring of the handset, including the connections to the switch, are shown in Figure 8.

The cable entry into the handset was sealed by using a rubber gland molded onto the cable. This gland was clamped in the handset handle by the switch plate. Tests on this gland demonstrated that a water-tight seal was formed and that the cable was clamped sufficiently to withstand a 25 pound pull test.

3.4 Earphone.

3.4.1 Requirements.

The important design requirements for the earphone were as follows:

- (a) A shock-proof, blast-proof earphone capable of meeting the service condition requirements of SCL-4195.
- (b) The weight, thickness and size shall be a minimum.
- (c) Frequency Response and level shall meet the requirements of SCL-4195.
- (d) The receiver end of the handset must fit between combat helmet liner and the ear.

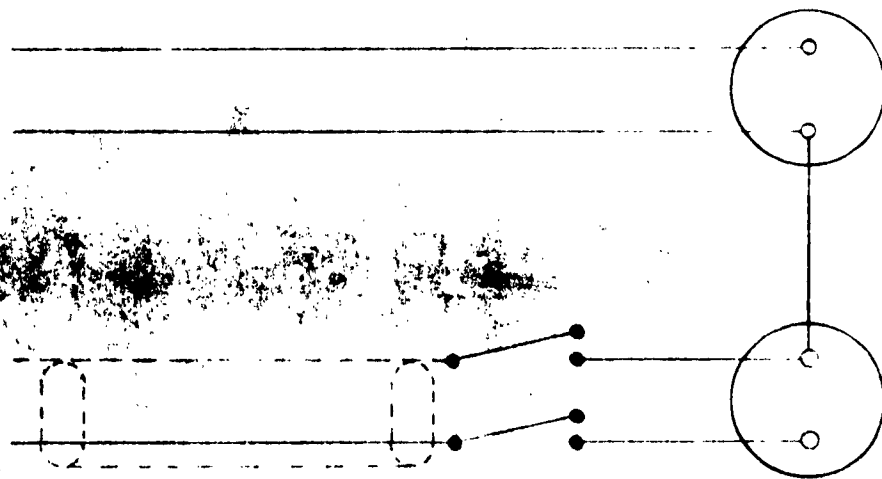


FIGURE 7.

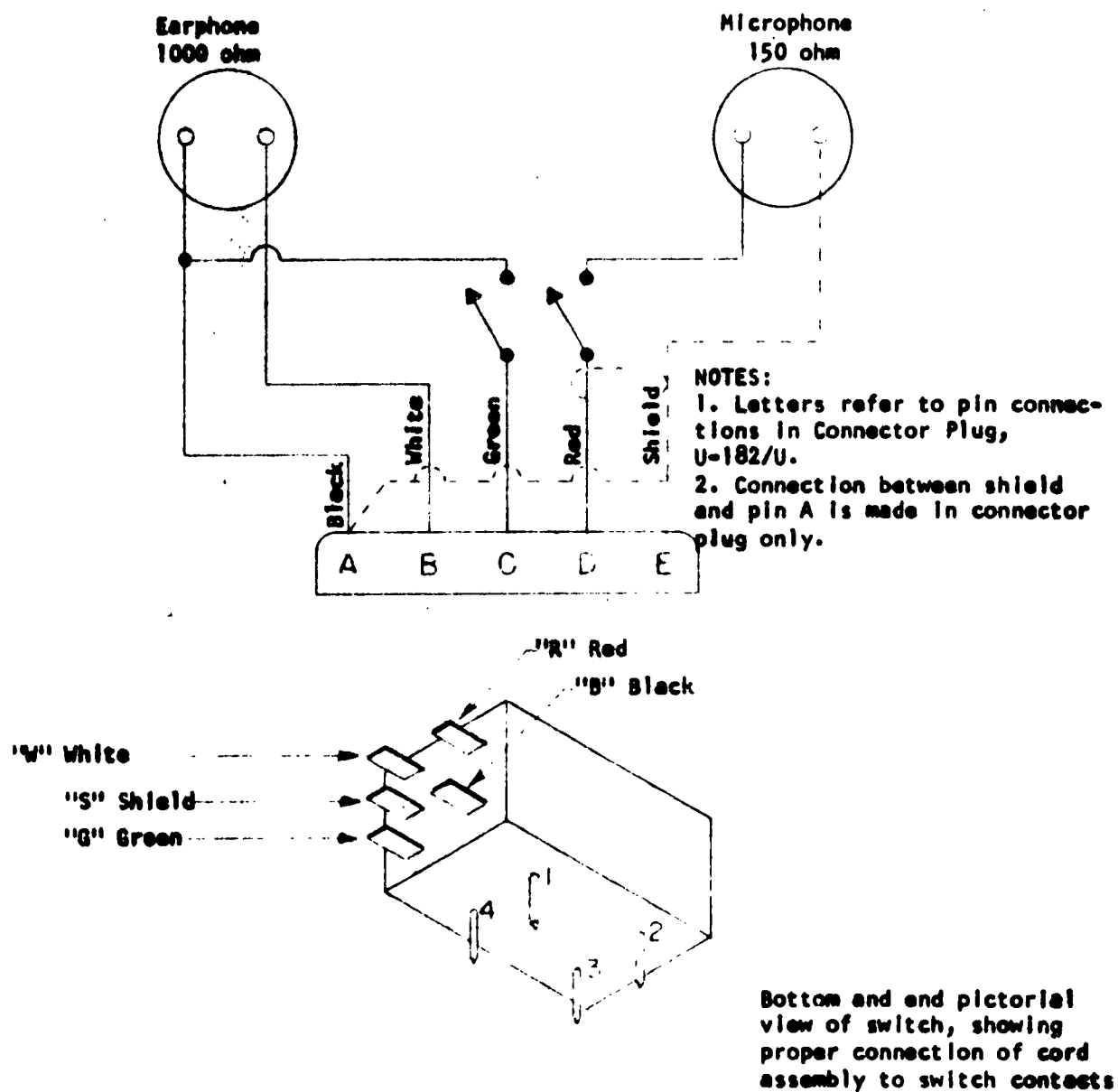


FIGURE 8.

3.4.2 Development.

To achieve an earphone with minimum thickness, a magnetic structure using Indox V magnetic material was designed. The characteristics of this material would allow a reduction in thickness, at the cost of a slight increase in area, when compared with Alnico V. This magnet was combined with Armco front and back plates and a steel center pole piece to complete the magnetic structure.

It was the original intention of the contractor to mold the above magnetic structure into the handset handle. However, the design approach was dropped because of the considerable increase in the cost of field repair that would have resulted.

As an alternate to this design, the magnetic structure was molded into a self contained modular package providing automatic centering of the diaphragm and voice coil assembly and pin terminals for electrical connection to the "fuzz buttons".

The requirement for a transformer was eliminated by using #50 gauge copper wire for the voice coil and winding a multi-layer coil with 1000 ohms impedance.

A sectioned drawing of the earphone is shown in Figure 9.

Earphone specifications are as follows:

- (a) Level: 107.5 db re .0002 dynes/cm² for 1 mw input.
- (b) Response: 300 to 3500, within the envelope shown in Figure 10.
- (c) Magnet Material: Indox V.
- (d) Plastic Material: Glass filled nylon.
- (e) Diaphragm and Moisture Barrier Material: Polyethylene Terephthalate (mylar)
- (f) Impedance: 1000 ohms. A drawing of the earphone is shown in Figure 9.

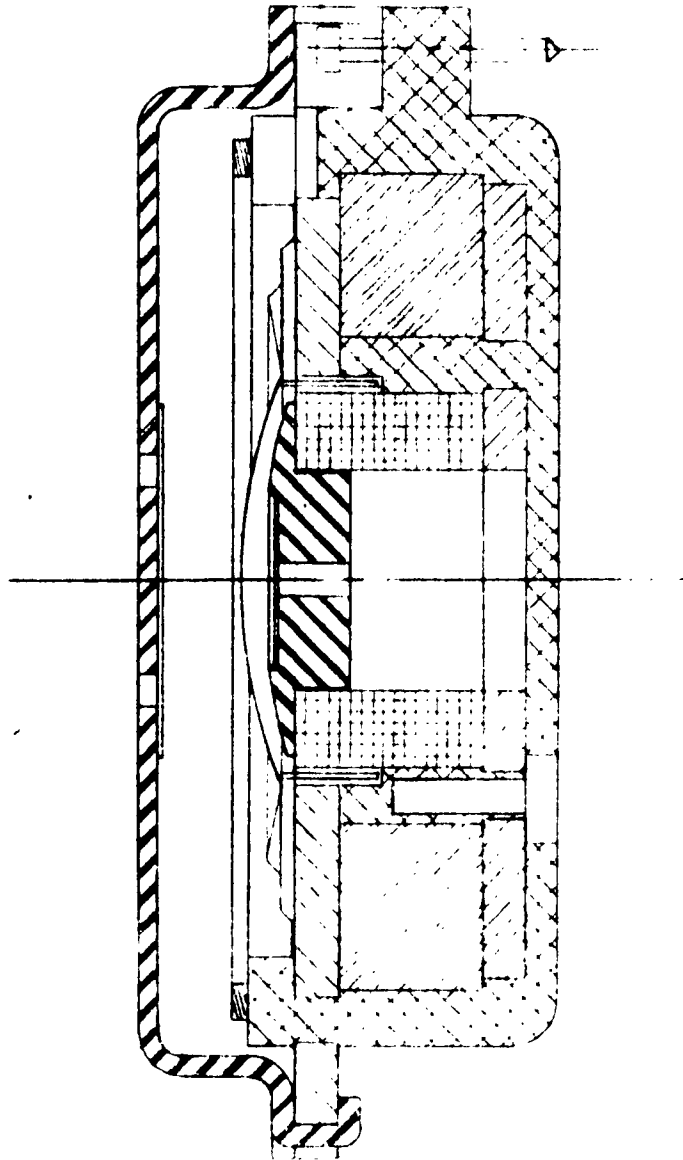
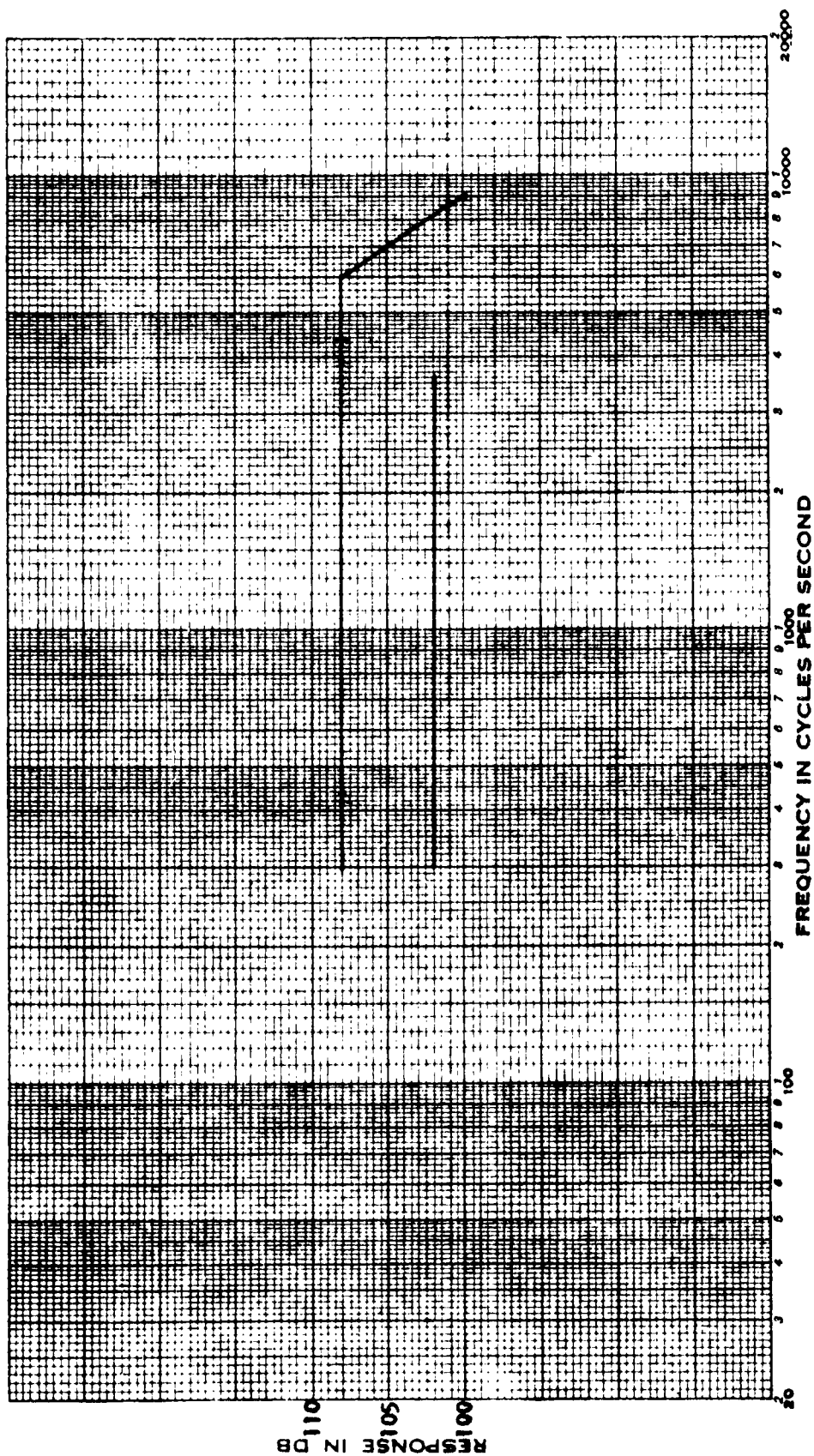


FIGURE 9.

EARPHONE RESPONSE ENVELOPE

MODEL _____ SOUND PRESSURE _____ DB
 FOR _____ REFERENCE: 0 DB= 0002 dynes/cm²
 Z _____ OHMS. TRANS. _____ DB/DIV. MICROPHONE PLACEMENT _____
 RECORD _____ SPECIAL NOTES 1 milliwatt power input _____
 DATE _____



Electro-Voice

RUN BY _____ CHECKED BY _____

FIGURE 10.

3.5 Microphone.

3.5.1 Requirements.

The important design requirements for the microphone were as follows:

- (a) A shock-proof, blast-proof microphone capable of meeting the service condition requirements of SCL-4195.
- (b) The microphone shall be noise-cancelling.
- (c) The sensitivity shall exceed -56 dbm for 28 dynes/cm² sound pressure.
- (d) The frequency response and level shall meet the requirements of SCL-4195.

3.5.2 Development.

At the outset of the design work on the microphone, the requirement for a noise-cancelling microphone was questioned, since this requirement would be one of the primary determinants of unit cost, the noise-cancelling microphone definitely costing more.

This increase in cost would result from the increased number of parts required, the increased control of processes, and the increased testing requirements. During discussions with Signal Corps representatives, it was determined that the noise-cancelling requirement could be eliminated for the following reasons:

- (a) The noise-cancelling requirement is not necessary in a large number of applications.
- (b) Those applications requiring a noise-cancelling microphone are generally covered by other transducers (i.e., the handset-microphone H-161()/GR and the H-138/GR handset).
- (c) The positioning of a pressure type microphone in front of the mouth is less critical than that in a gradient, noise-cancelling type.

The noise-cancelling requirement was deleted in Amendment 1 to SCL-4195, dated 10 August 1961.

The microphone front plate is insert molded into a plastic assembly that provides automatic centering of the diaphragm, forms damping slots around the magnet, and supports the contact pins. The material used is a glass filled Nylon, a very high heat resistant, stable material.

This assembly when assembled with an Alnico V magnet and drawn steel cup forms the magnetic structure.

By using a steel front cover, complete shielding of the voice coil is accomplished and the requirements for induced voltage pickup are met.

The requirements for a transformer is eliminated by winding a 150 ohm voice coil using #49 gauge wire.

A sectioned drawing of the microphone is shown in Figure 11.

The microphone specifications are as follows:

- (a) Level: -56 dbm for 28 dynes/cm² sound pressure.
- (b) Frequency Response: Within the limits shown in Figure 12.
- (c) Impedance: 150 ohms.
- (d) Induced Voltage: Less than 16 db above 1000 cps sensitivity for one oersted.
- (e) Diaphragm and Moisture Barrier Material: Polyethylene Terephthalate (Mylar).

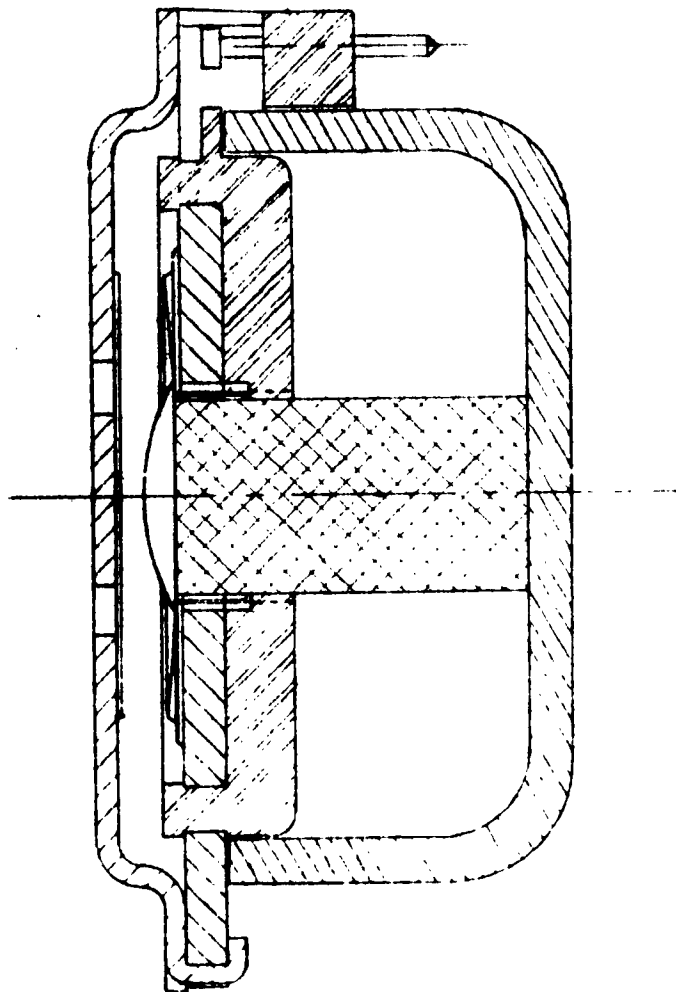
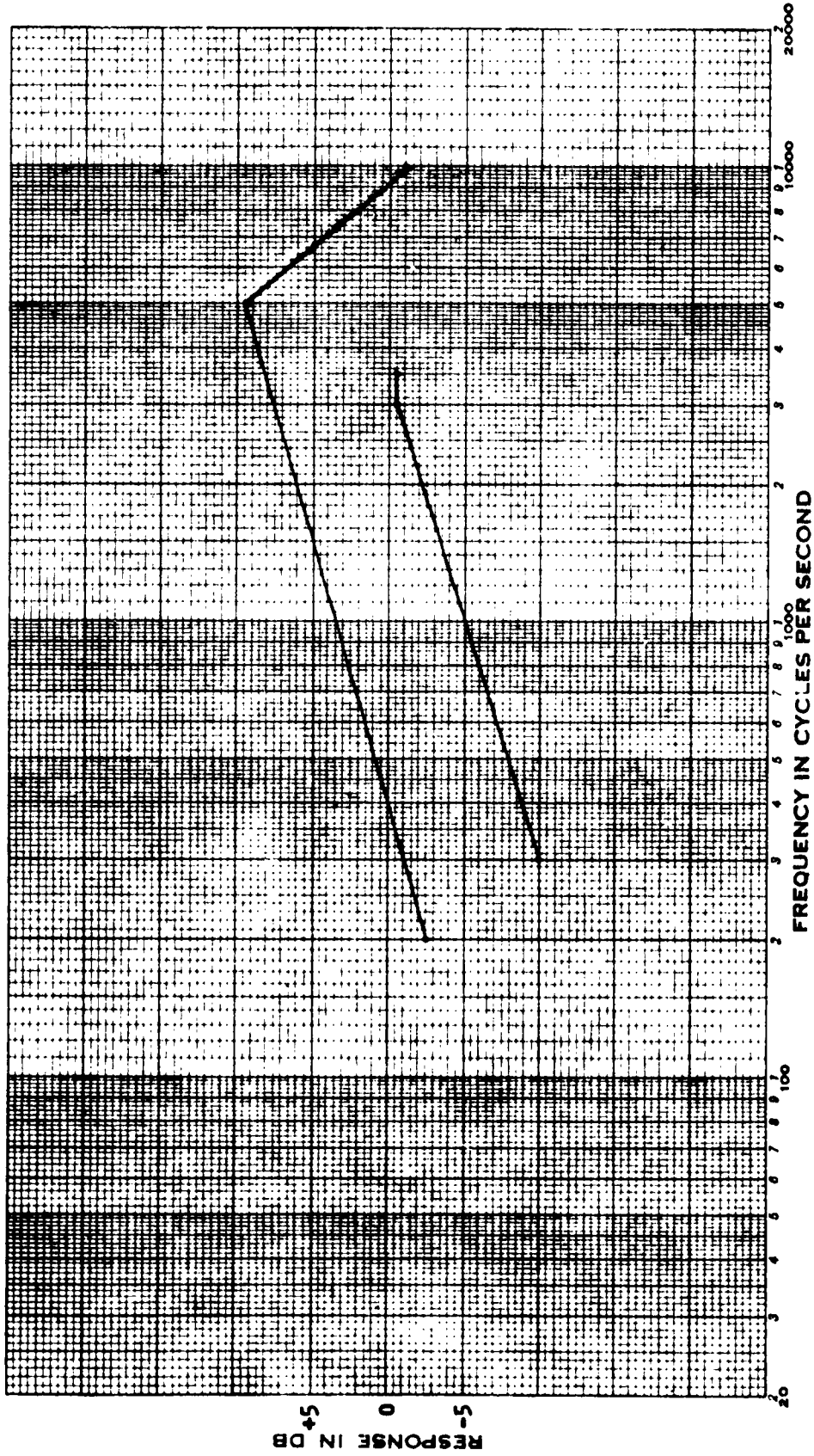


FIGURE 11.

MICROPHONE RESPONSE ENVELOPE

MODEL _____ SOUND PRESSURE _____ DB
 FOR _____ REFERENCE: 0 DB=
 Z _____ OHMS. TRANS. _____ DB/DIV. MICROPHONE PLACEMENT _____
 RECORD _____ SPECIAL NOTES _____
 DATE _____



Electro-Voice

RUN BY _____ CHECKED BY _____

FIGURE 12.

3.6 Test of Engineering Models.

Delivery of six engineering models was made on January 22, 1962. Tests performed at the time of delivery disclosed that the cable and wiring used on these models would not work with the VRC-12 radio equipment because of electrical noise in the control current.

It was also noted during initial tests performed on the models that the pins used to make contact were fragile and should be strengthened, and that the exposed portions of the fine wire should be potted to prevent even small displacements during vibration and shock.

Additional handsets were constructed incorporating the changes required to correct the deficiencies noted above, and these handsets were delivered to the Signal Corps.

Service condition tests were then performed at the Signal Corps Laboratories on the models supplied.

As a result of service tests performed on the engineering models, further corrective action was required. Because of water leakage on the microphone, the following changes were made:

- (a) A rubber gasket material with improved set characteristics was used.
- (b) An additional .005 inch compression of the gasket was provided.

Because of failure of the spring return mechanism during the switch life test, the following changes were made:

- (a) A spring, hardened after forming was used.
- (b) Increased clearance between the bar and the boot was provided.

(c) The switch bracket tooling was changed to improve the alignment of the spring with the electrical switch mechanism. The contractor also performed life tests on the electrical switch mechanism to insure proper operation through 500,000 cycles.

As the result of the failure of an earphone cap during the drop test, the wall thickness on both the earphone and microphone caps was increased to provide additional impact strength.

4. SERVICE TEST MODELS.

The tests detailed in paragraphs 4.2 through 4.6 of SCL-4195 were performed on the twenty service test models as reported in the following paragraphs.

4.1 Visual and Mechanical Inspection and Continuity Test.

4.1.1 Description of Test.

Each handset was inspected for proper operation of the switch by talk-testing each unit. During the talk-test the microphone output was connected to drive the earphone. The operation of the switch and the wiring of the handset was tested by means of a continuity test performed between the terminals of the U-182/U connector and the insert terminations in the microphone and earphone cavities. Each switch was checked for evidence of binding or improper mechanical movement. All solder joints at the termination of the voice coil leads were examined for any evidence of poor solder joints. The mechanical fit of the earphone and microphone elements in the handset case was checked during assembly.

4.1.2 Test Results.

All of the units worked properly during the talk-out test. Results of the continuity tests on all units were satisfactory with the contact resistance of the switch contacts measuring less than 0.2 ohms. All transducer elements could be installed and removed without difficulty.

4.2 Earphone Tests.

4.2.1 Response Test.

4.2.1.1 Description of Test.

The earphone was mounted on a 6cc coupler designed in accordance with A.S.A. Standard Z24.9/1949 as shown in Figure 13. A Western Electric 640AA Condenser Microphone, calibrated at Bell Telephone Laboratories on November 30, 1960, was used as the measuring microphone and is shown with the coupler mounted on it. The calibrated voltage output of the 640AA microphone as a function of frequency is shown in Figure 14.

The Model 640AA microphone output, when driven by the test earphone, was recorded continuously using the mechanically coupled oscillator and recorder shown in Figure 13.

4.2.1.2 Test Results.

The frequency response of the twenty service test earphones is shown in Figures 15 through 24.

4.2.2 Impedance.

4.2.2.1 Description of Test.

The impedance of the earphones was measured by passing a current of 0.1 milliamperes through the earphone and measuring the voltage drop across the unit. This voltage drop multiplied by 104 gives the impedance of the earphone in ohms.

4.2.2.2 Results of the Tests.

The impedance of the twenty service test earphones is shown in Figure 25.

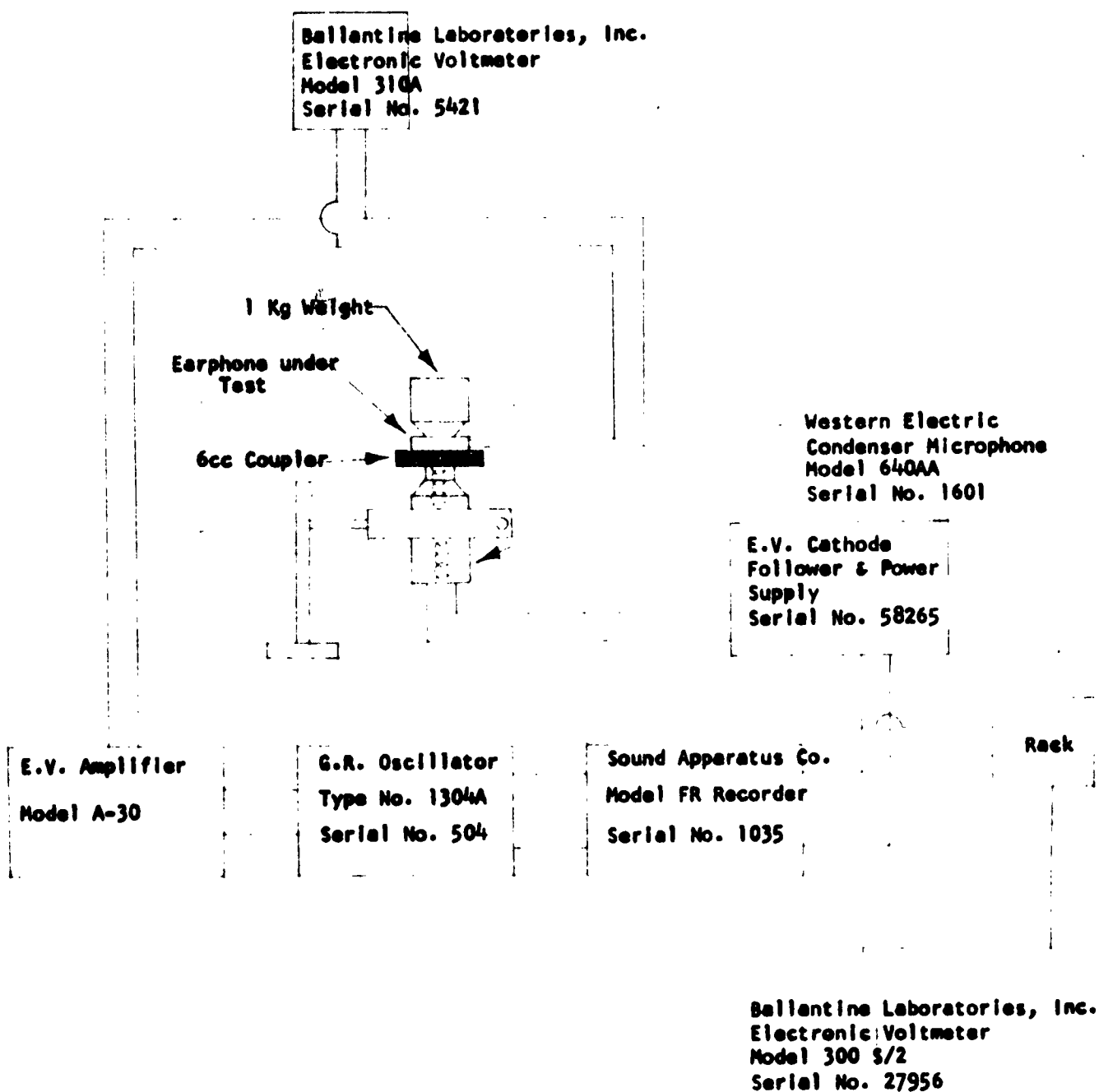
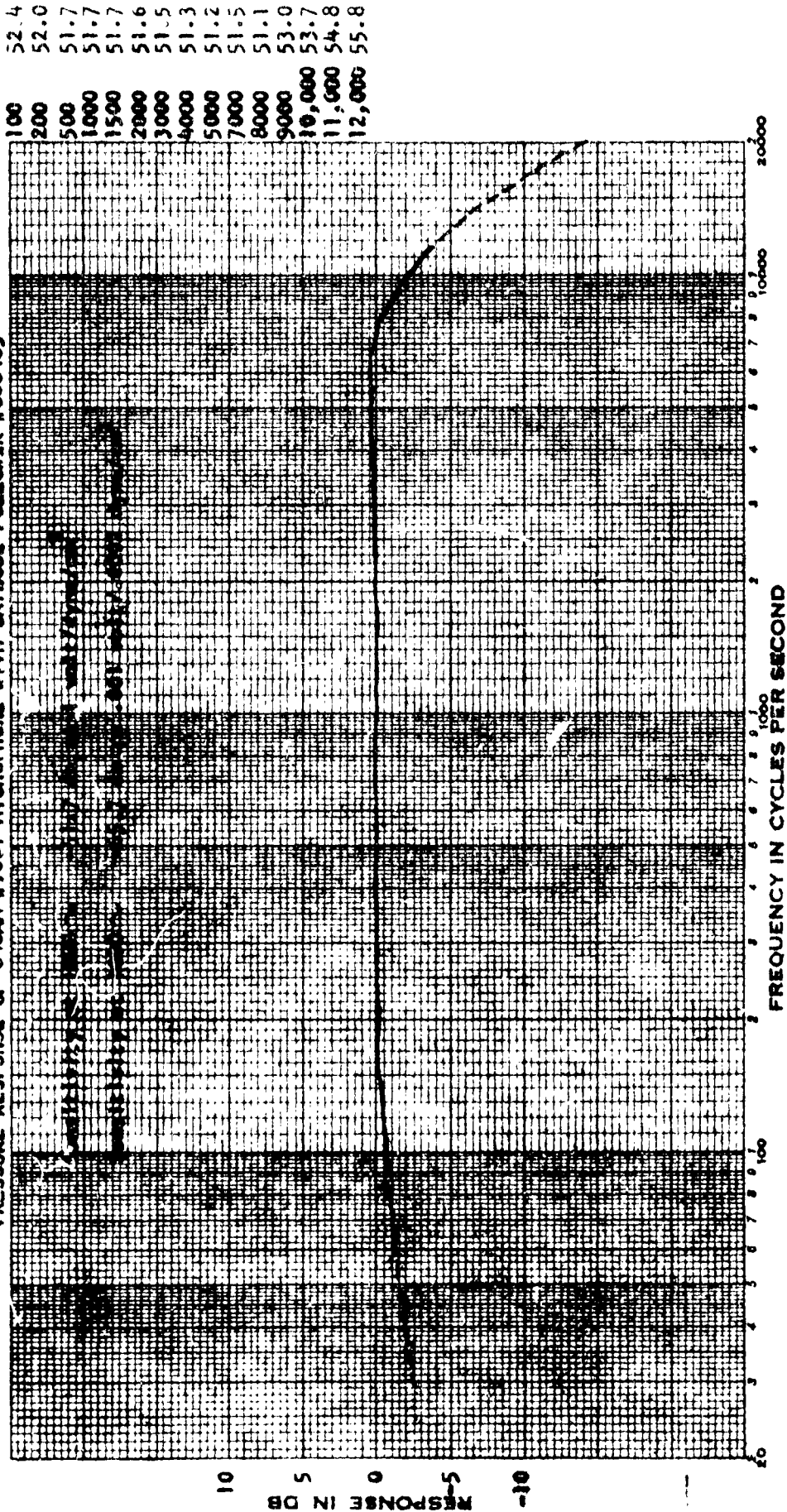


FIGURE 13.

MODEL _____
 FOR _____
 Z _____ CHMS. TRANS. _____ DB/DIV. 1/2
 RECORD _____ DATE 9-14-61

SOUND PRESSURE 114 DB 2
 REFERENCE 0 DB-0002 dyne/cm²
 MICROPHONE PLACEMENT 1/4 inch
 SPECIAL NOTES

PRESSURE RESPONSE OF 610AA #1601 MICROPHONE WITH CATHODE FOLLOWER #060403



Electro-Voice

RUN BY _____ CHECKED BY _____

FIGURE 14.

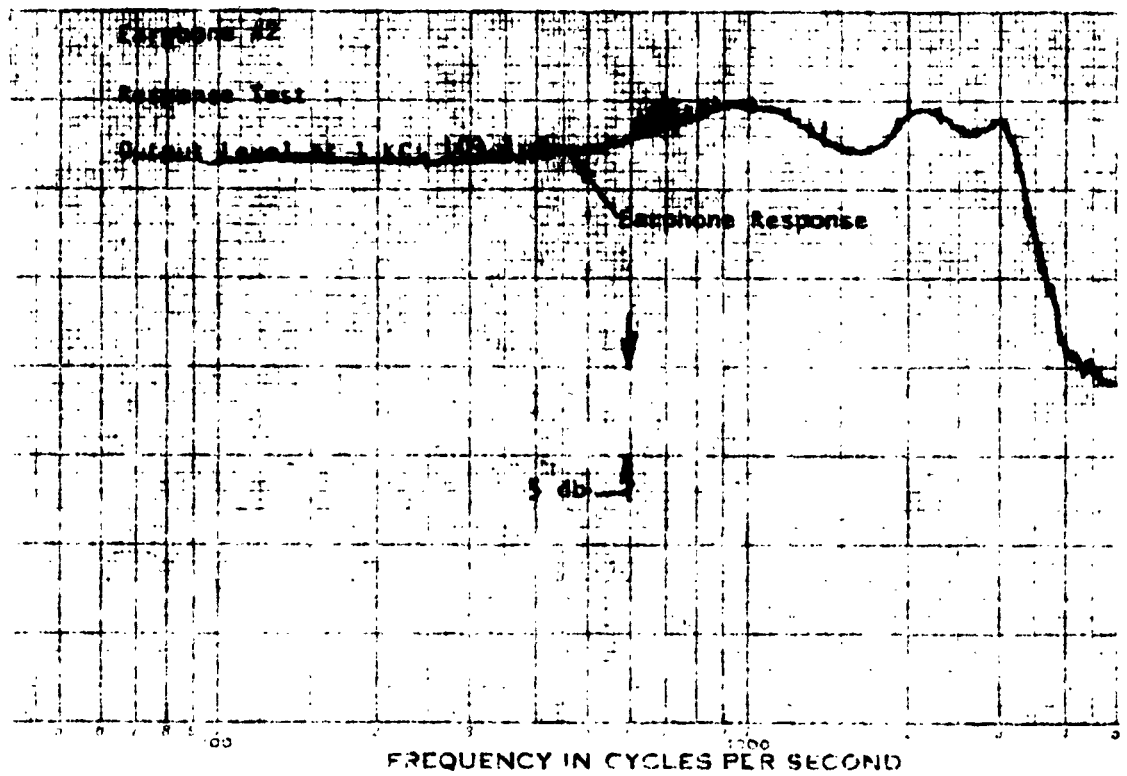
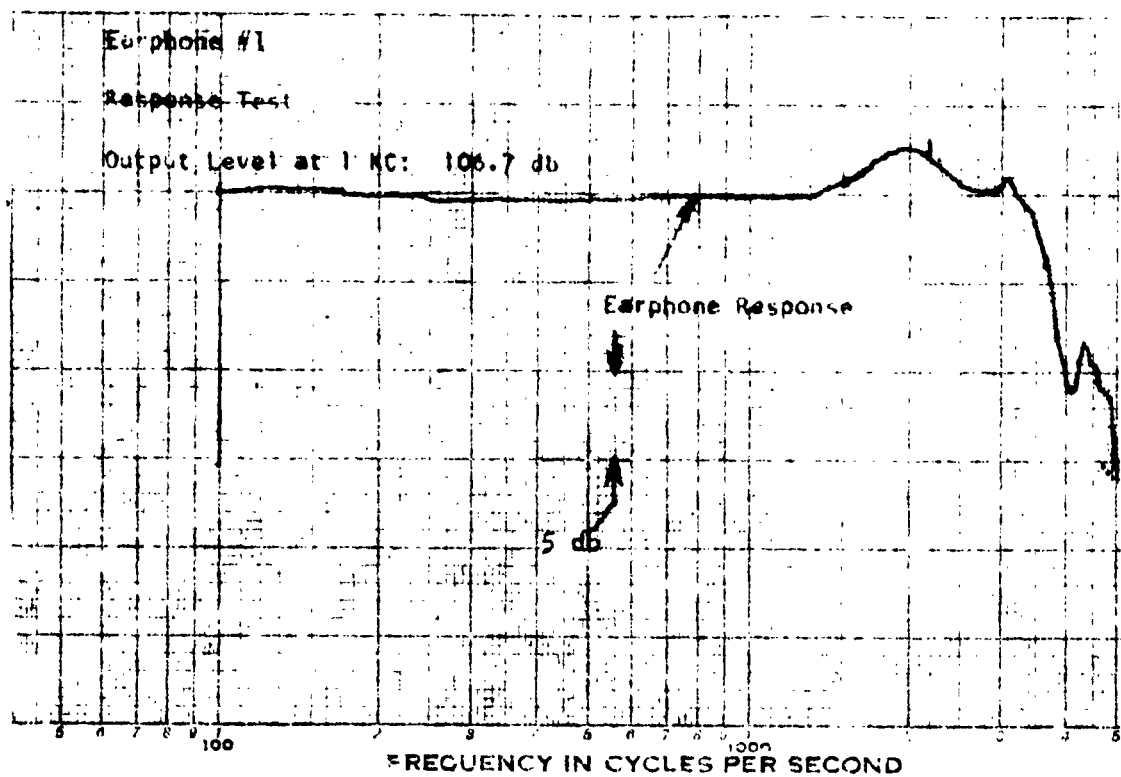


FIGURE 15.

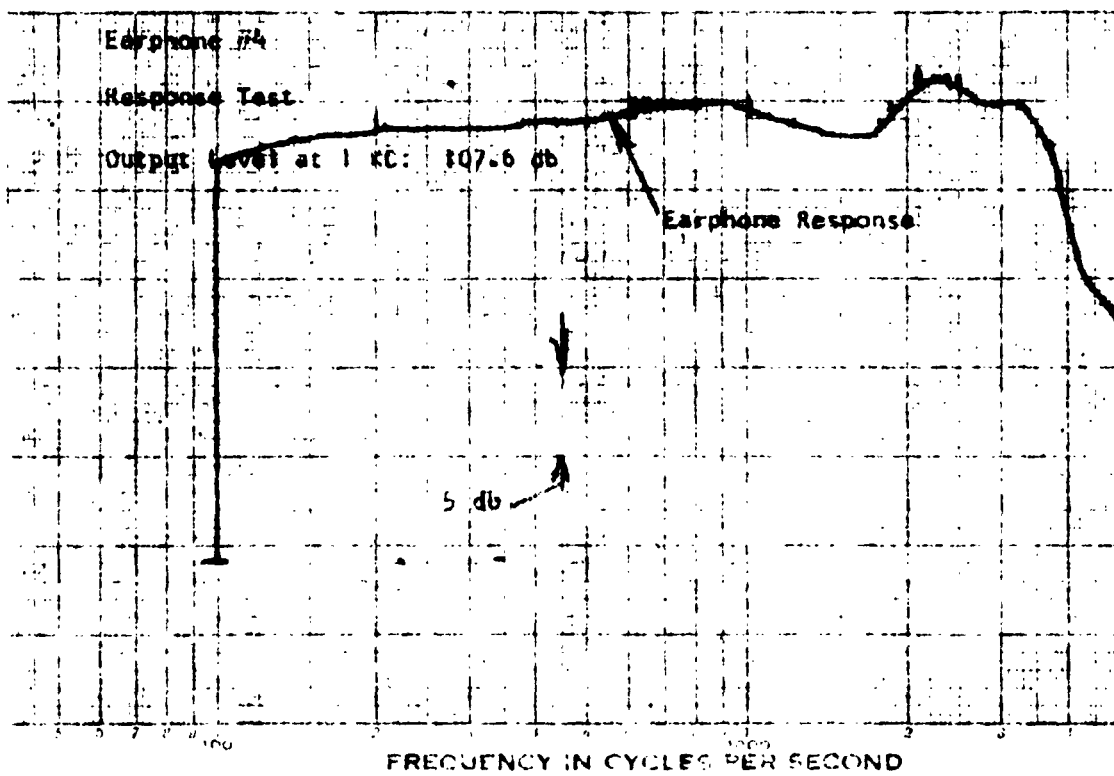
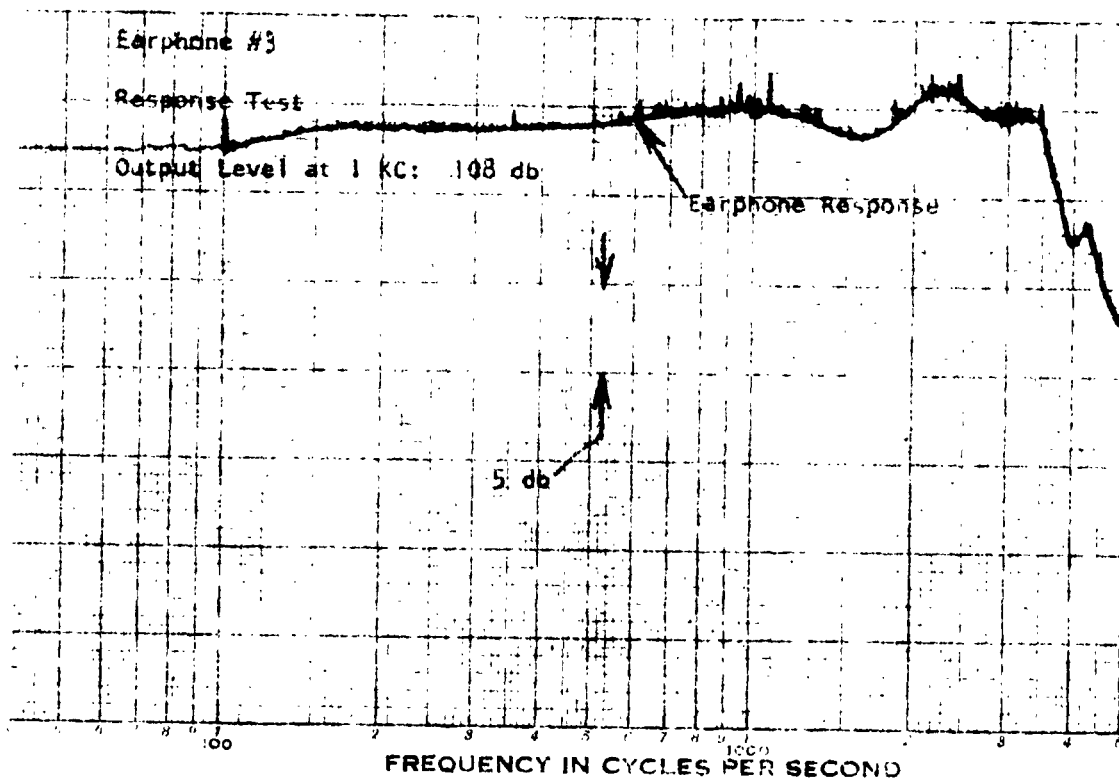


FIGURE 16.

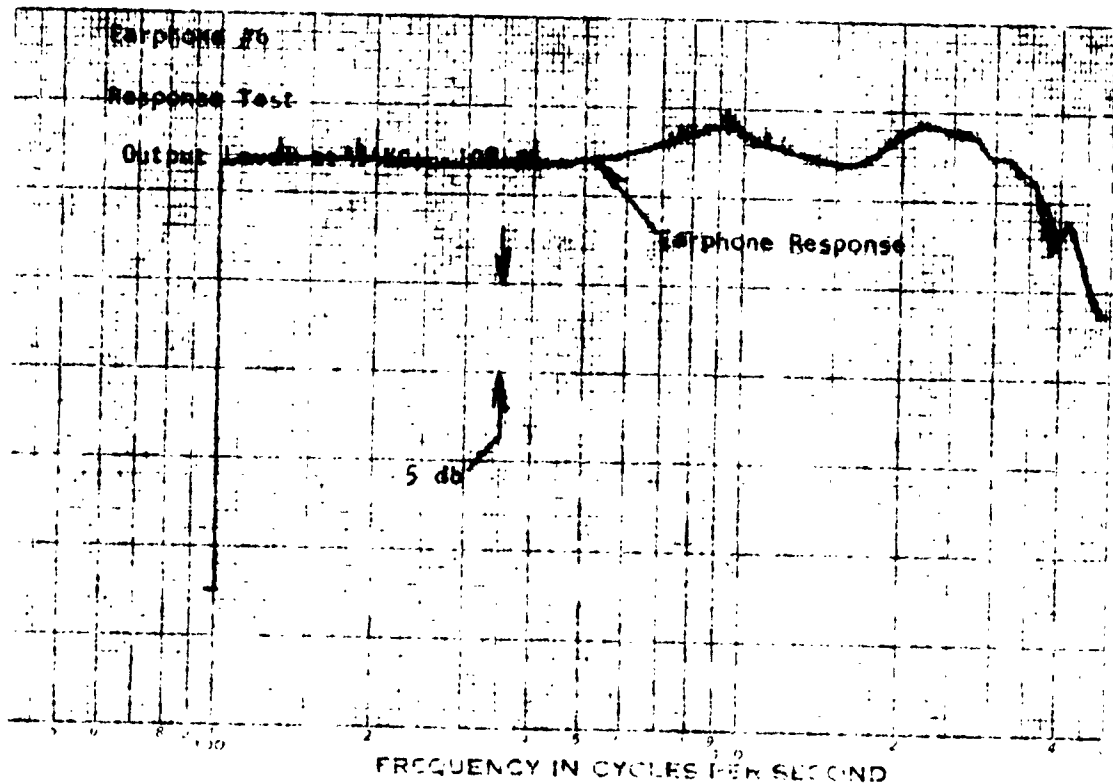
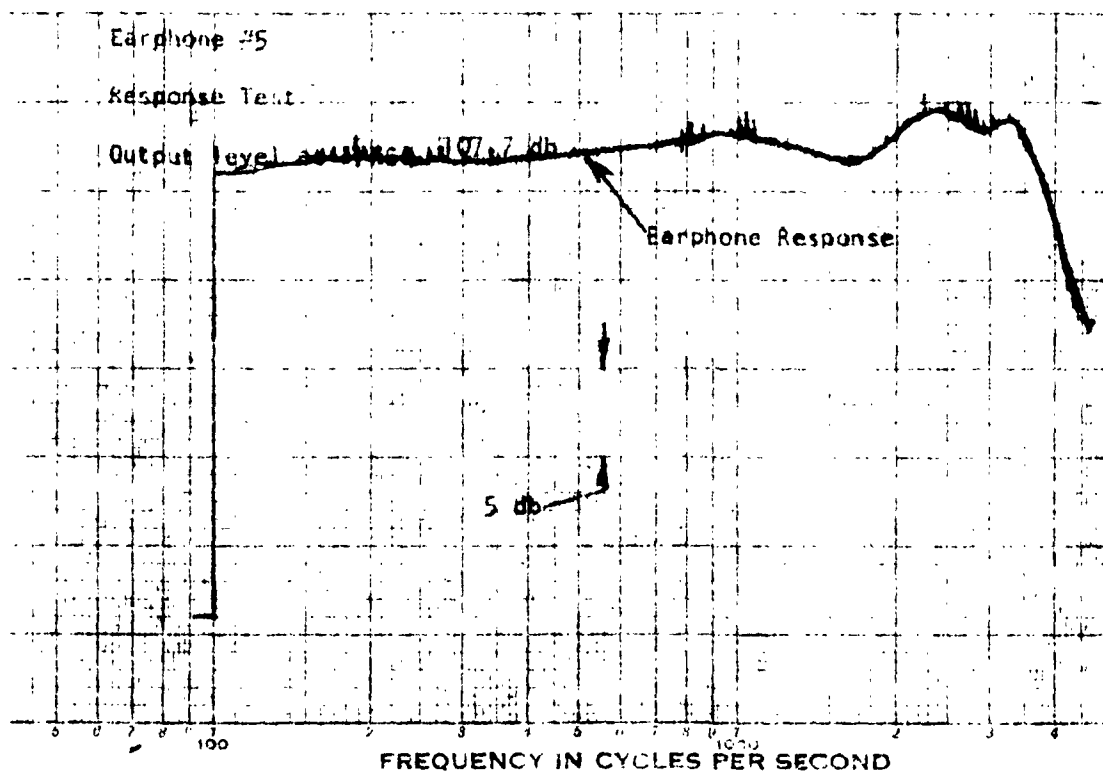


FIGURE 17.

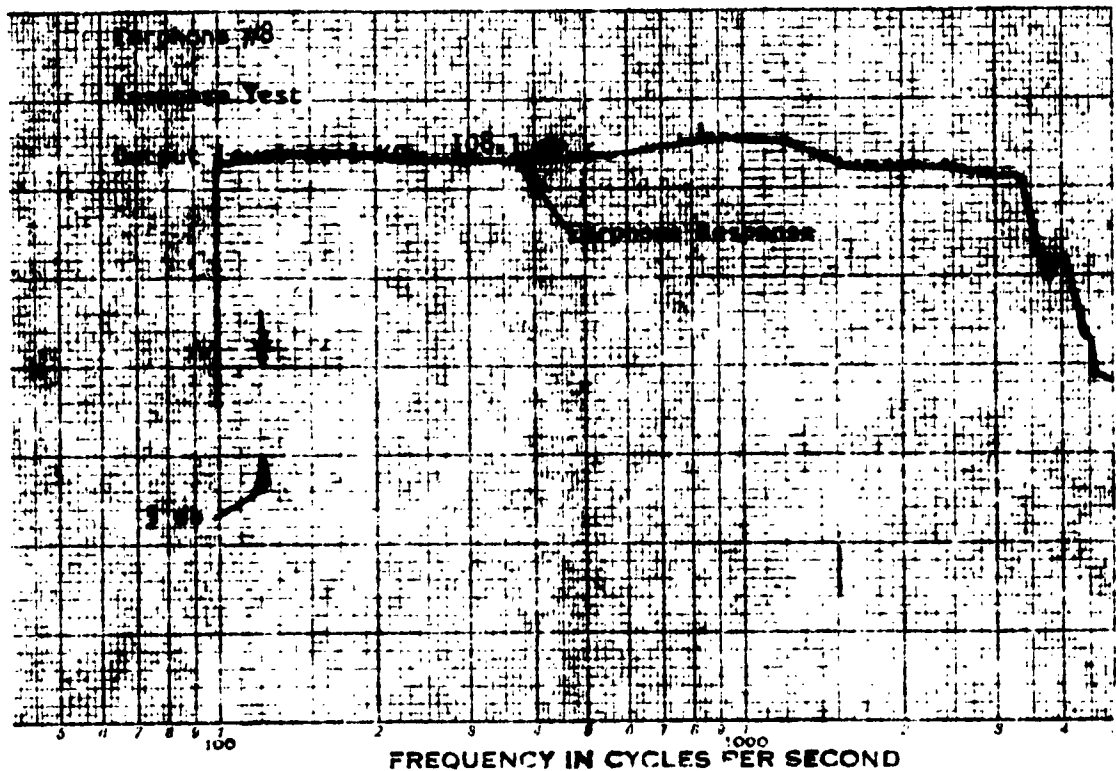
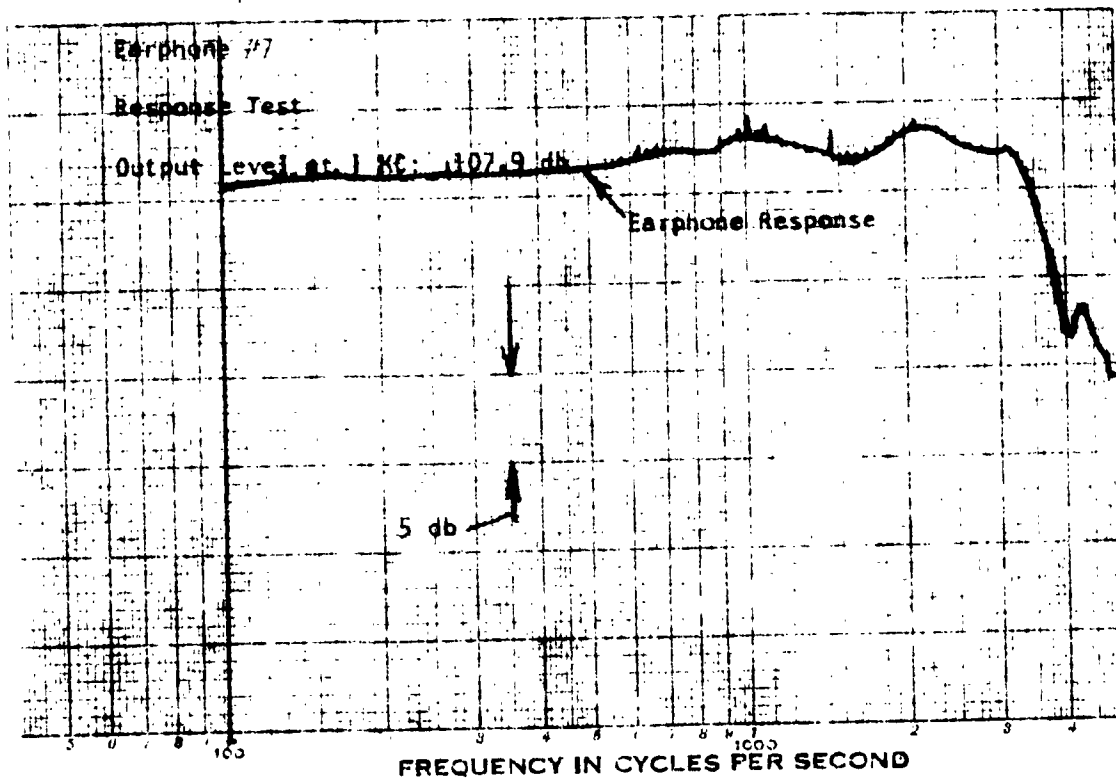


FIGURE 18.

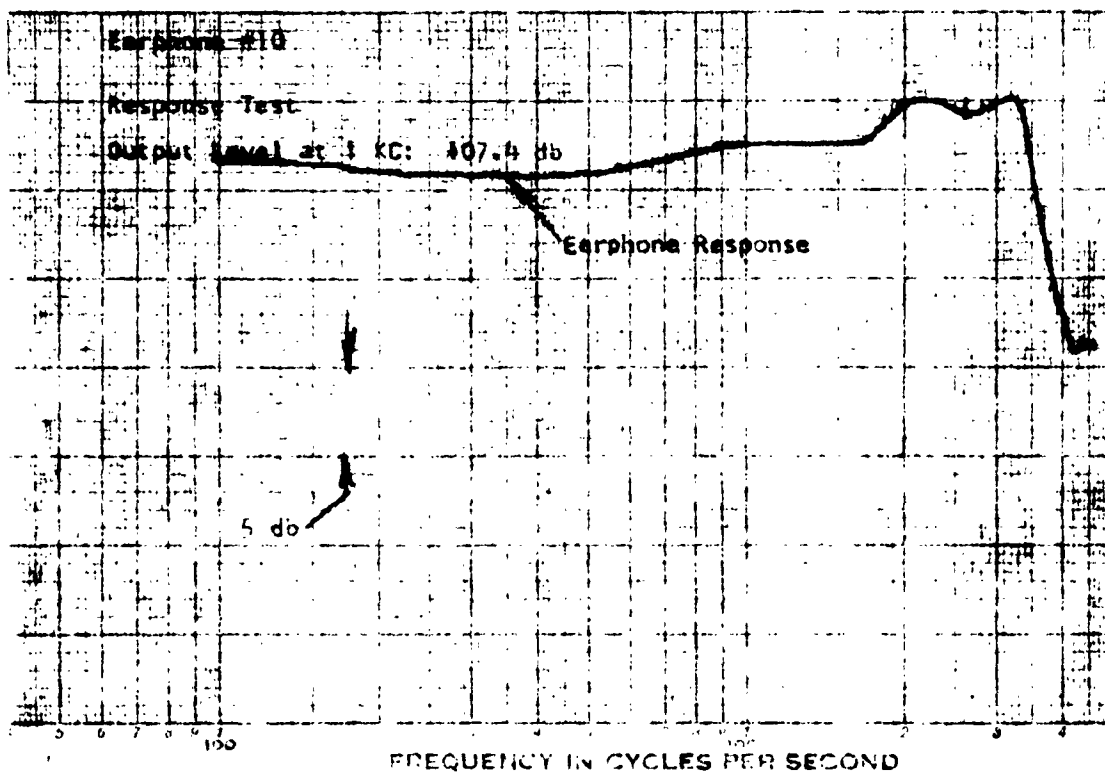
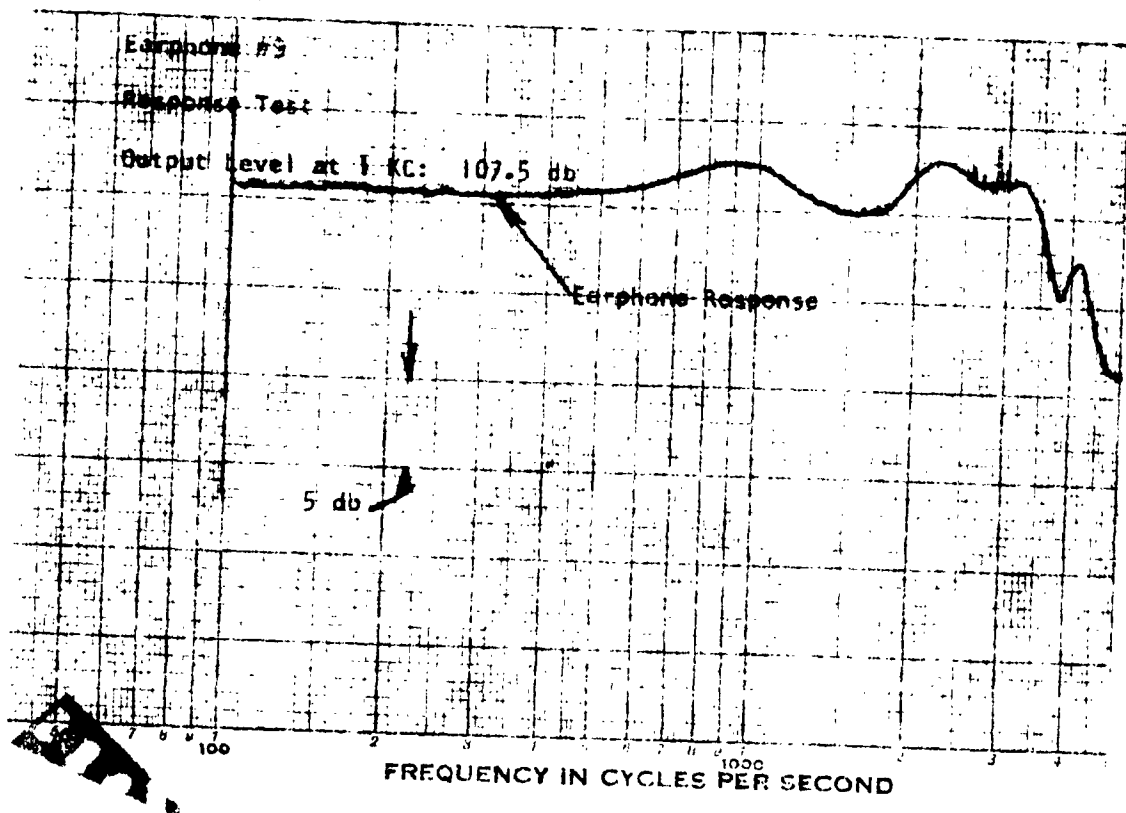


FIGURE 19.

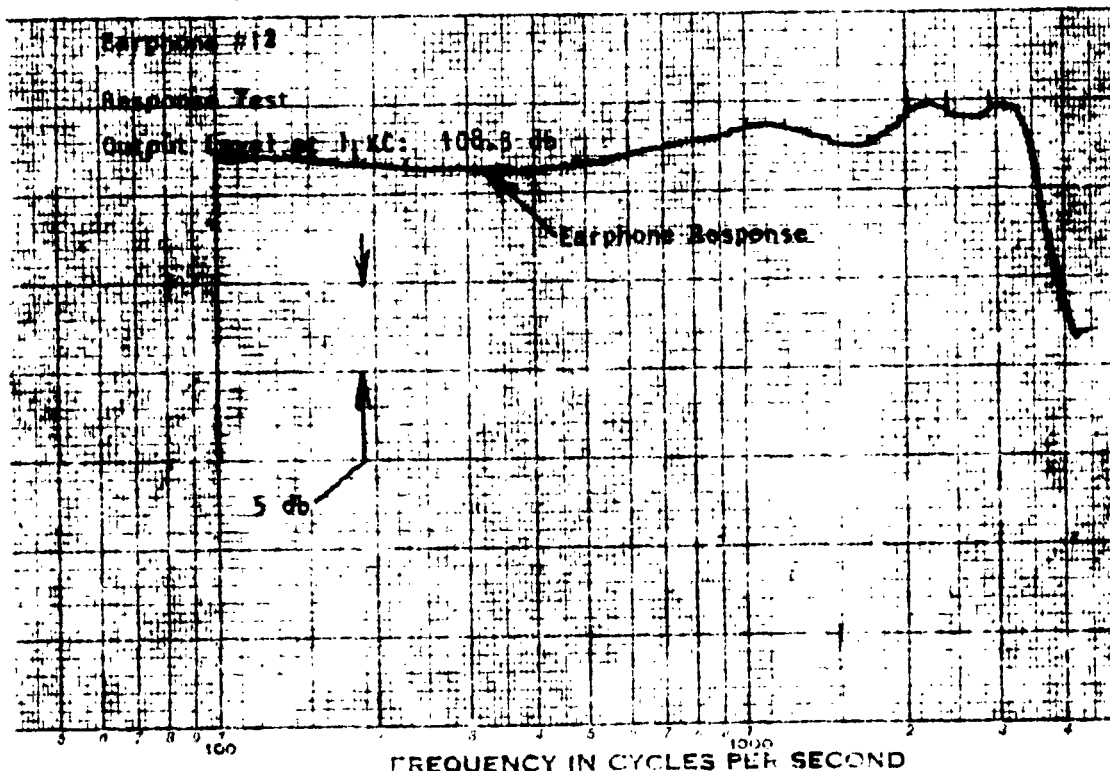
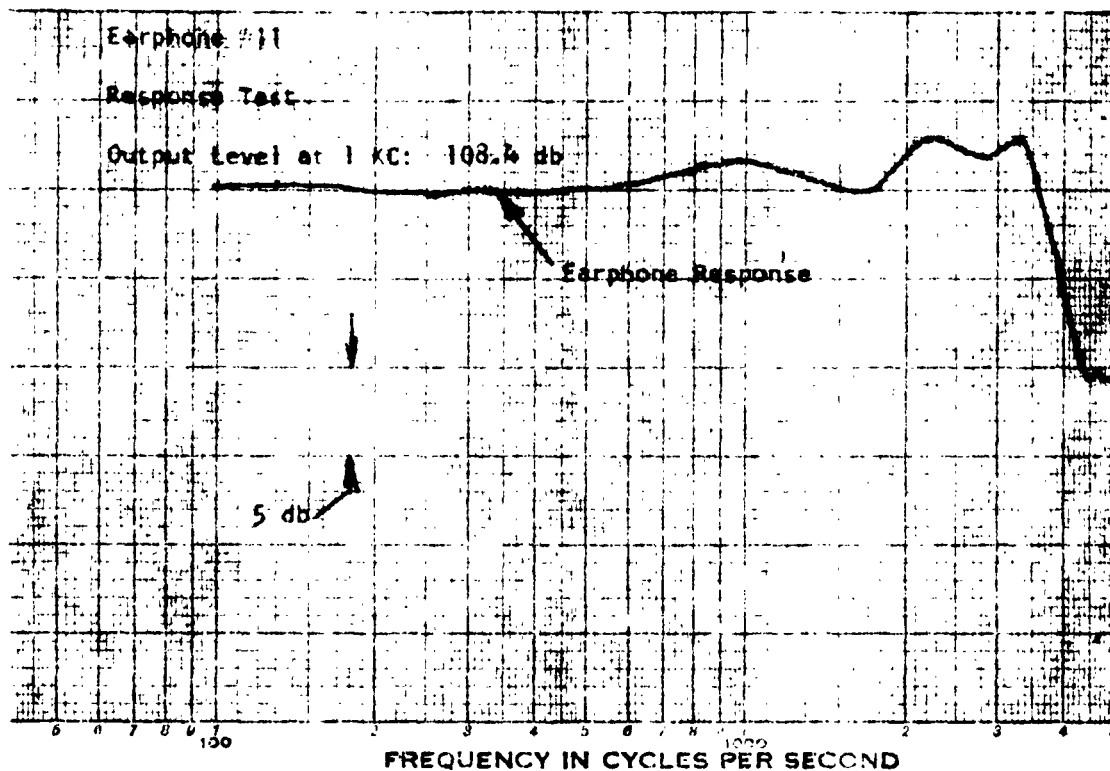


FIGURE 20.

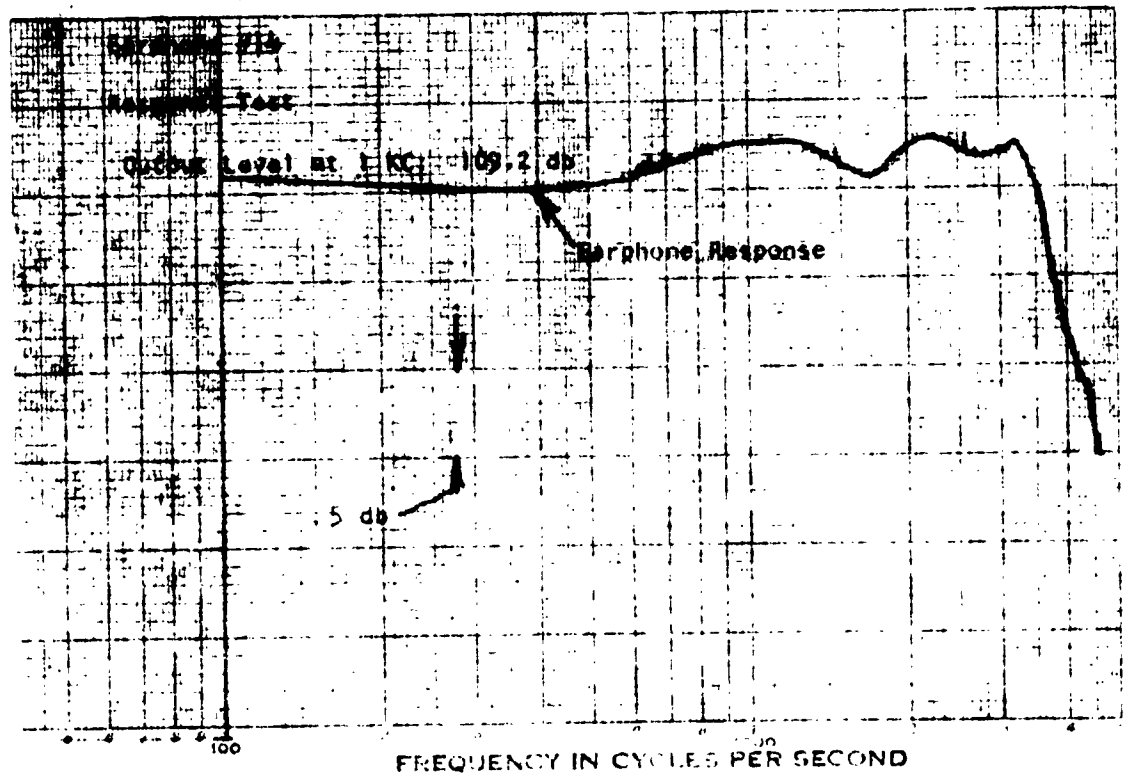
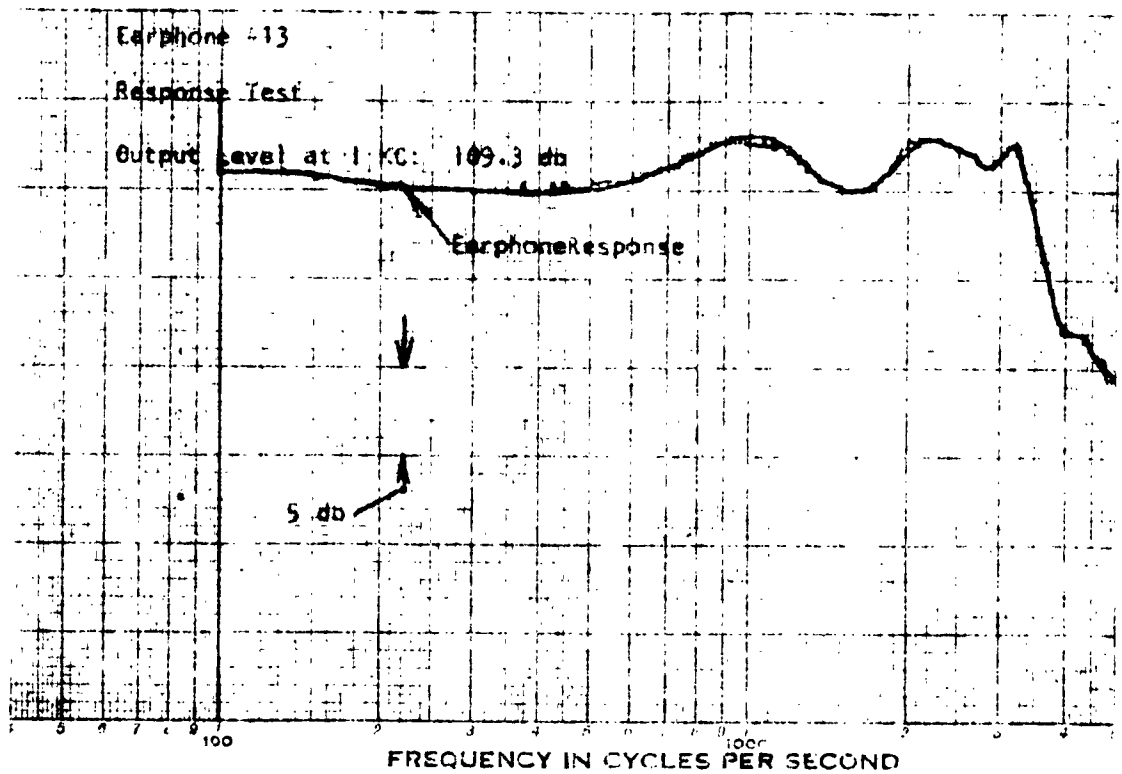


FIGURE 21.

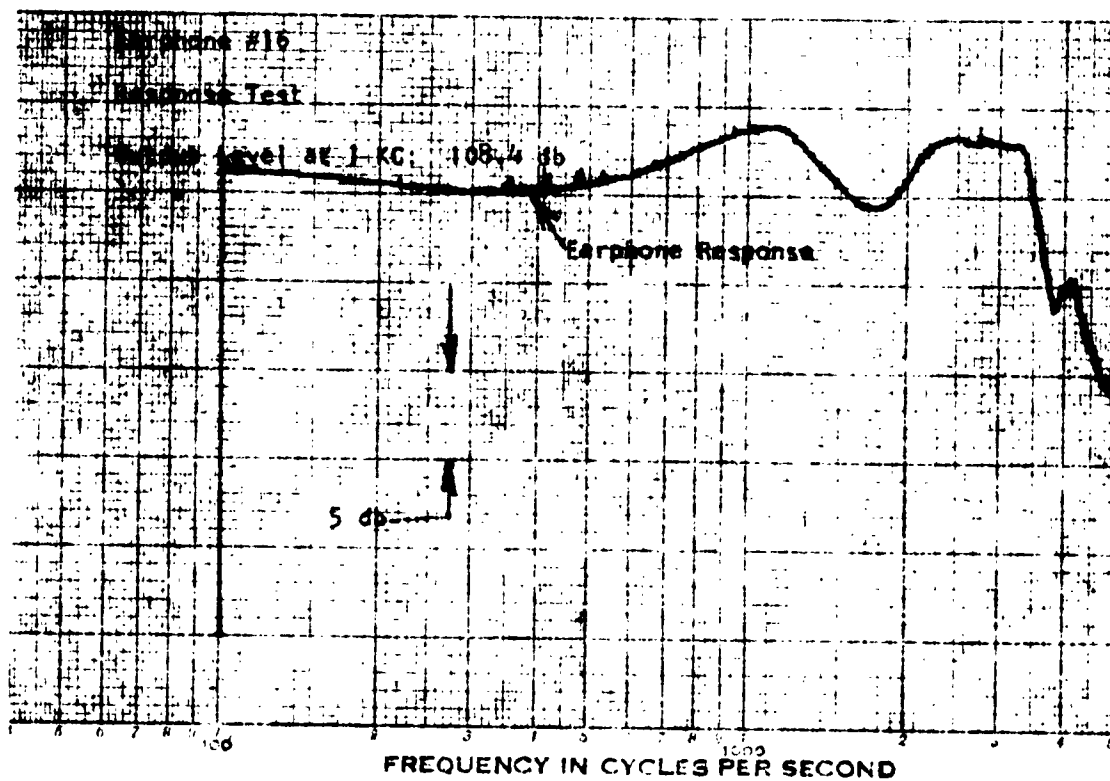
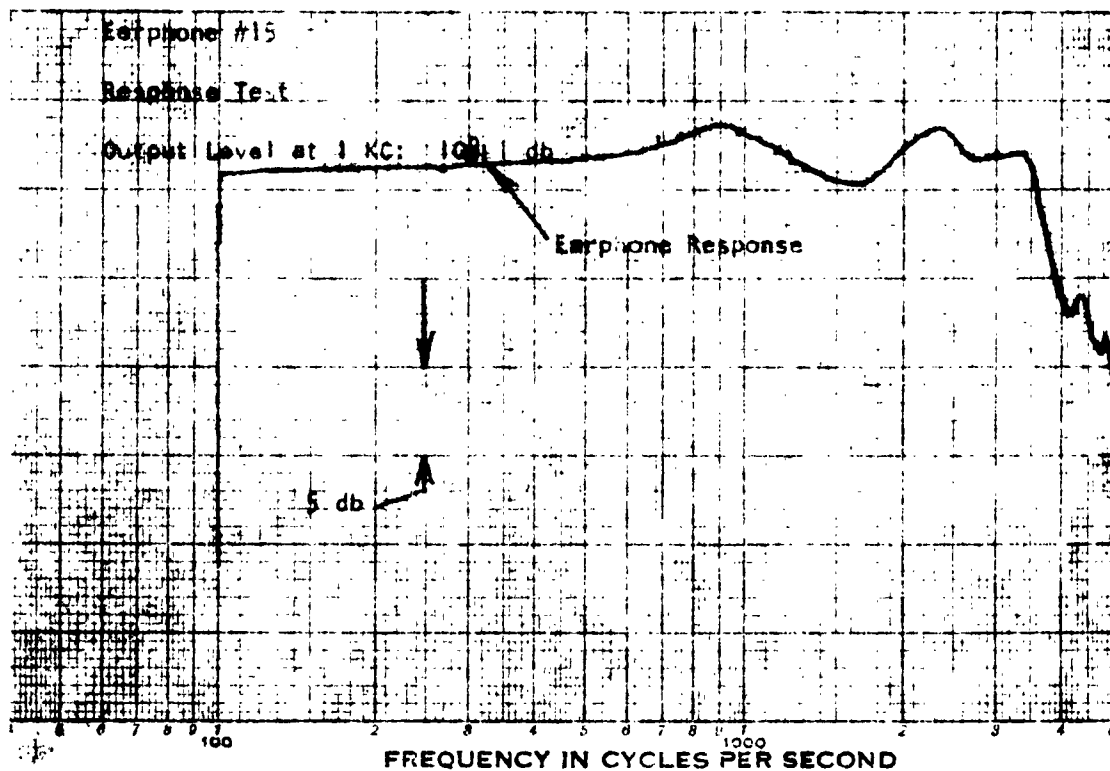


FIGURE 22.

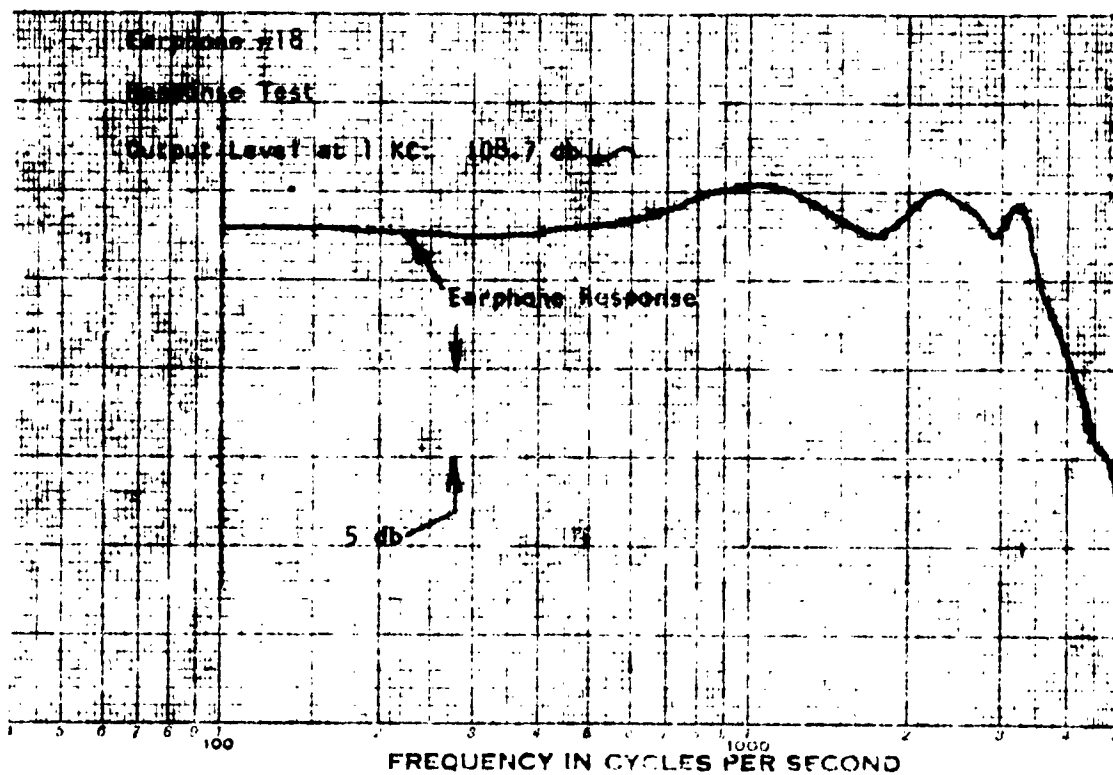
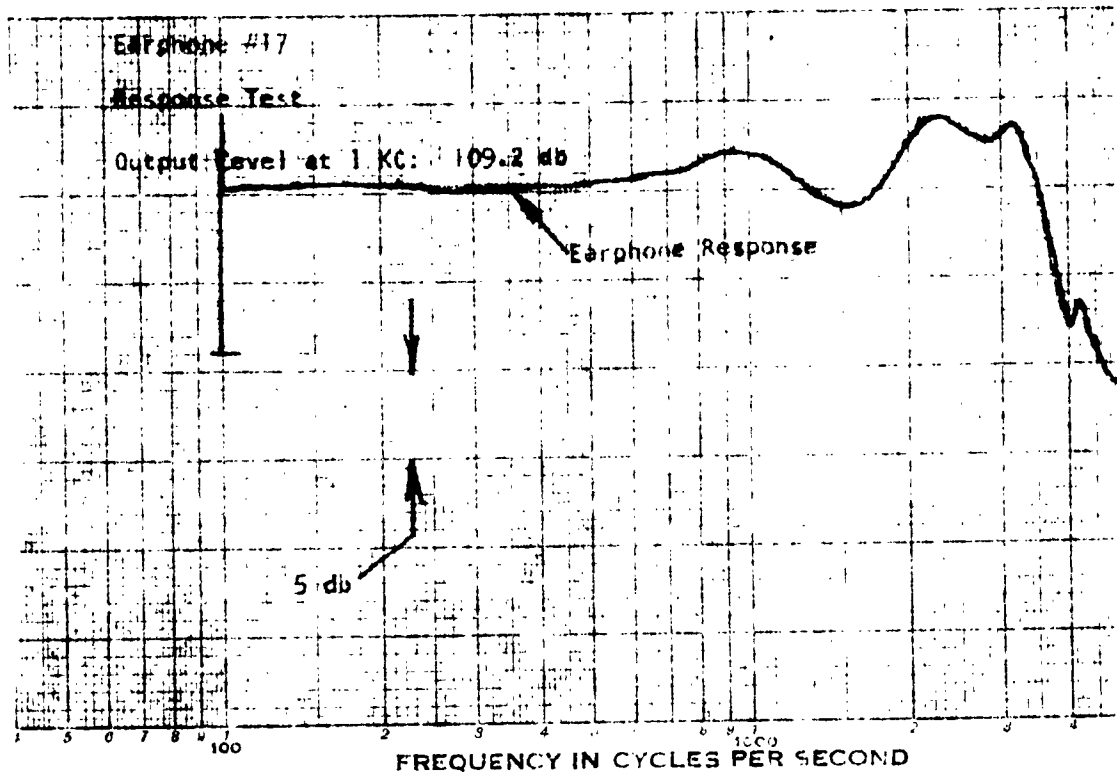


FIGURE 23.

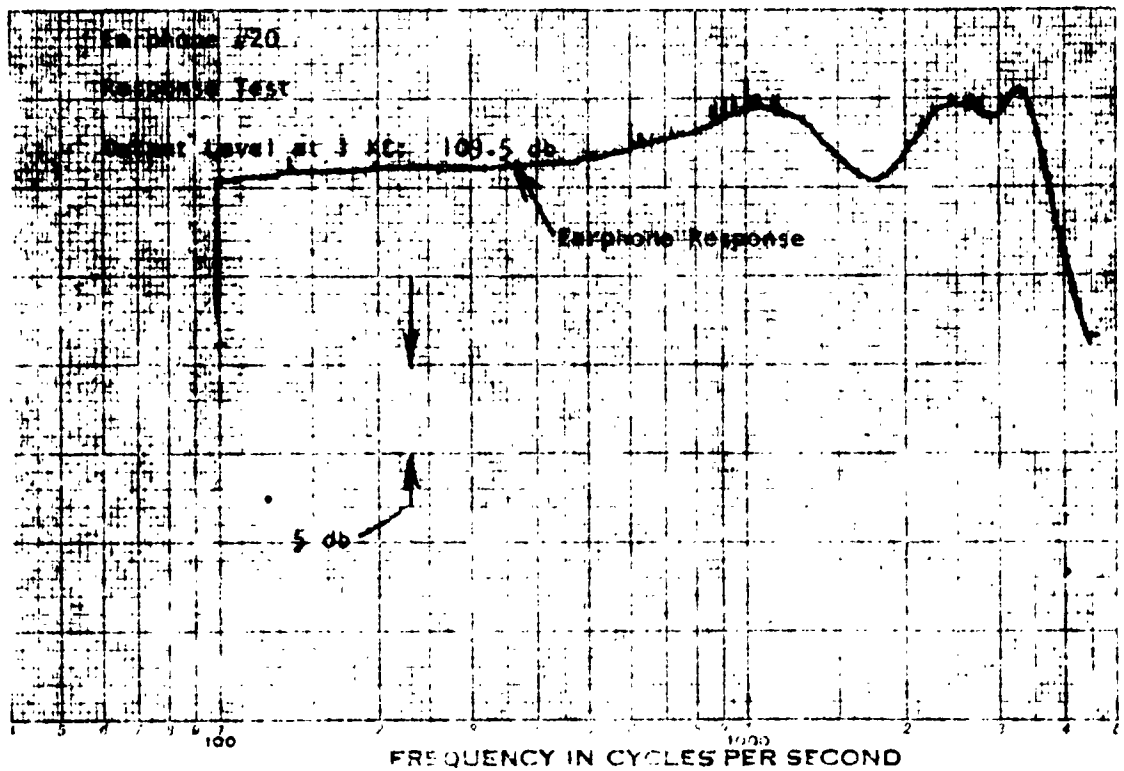
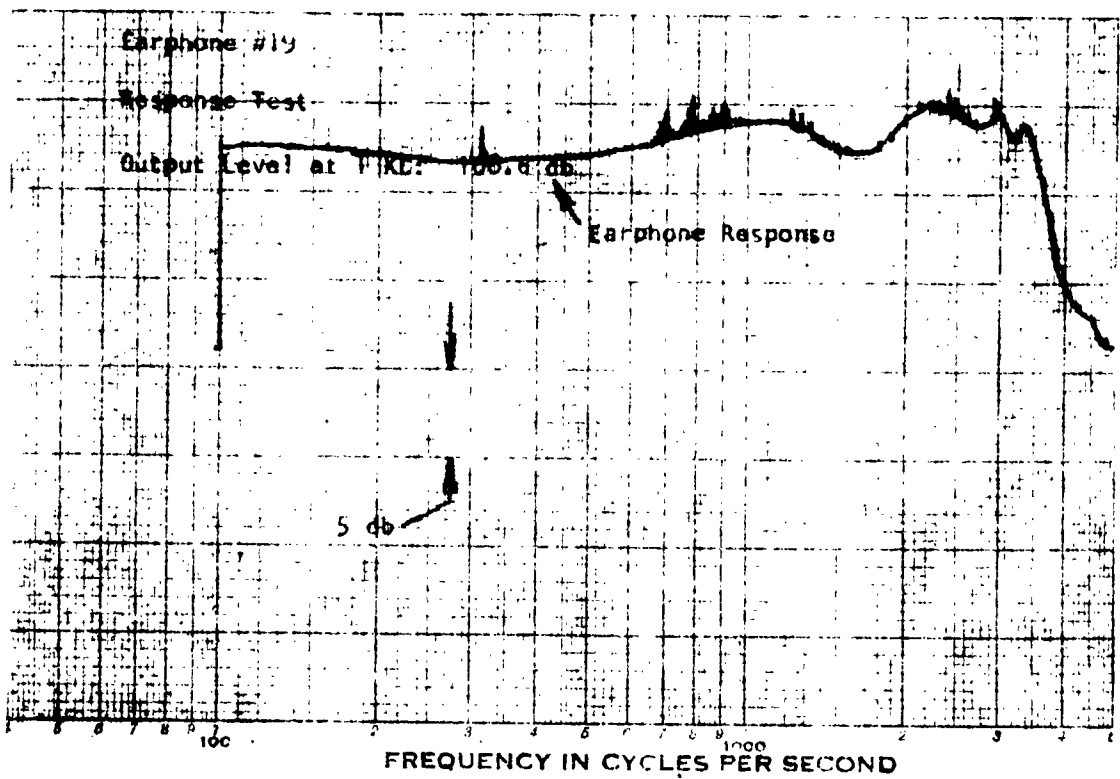


FIGURE 24.

EARPHONE IMPEDANCE AT 1 KC

HANDSET UNIT NO.	IMPEDANCE IN OHMS
1	970
2	1000
3	960
4	950
5	1000
6	960
7	950
8	960
9	970
10	960
11	980
12	970
13	970
14	980
15	950
16	950
17	980
18	950
19	950
20	980
21	960
22	970

FIGURE 25.

4.2.3 Earphone Distortion Test.

4.2.3.1 Description of Test.

With the earphone connected as shown in Figure 13 for the response test, and with the output of the 640AA connected to a Model 3308 Hewlett Packard Distortion Analyzer instead of the recorder, distortion measurements on three earphones were made at 100 cps intervals below 1000 cps and at 500 cps intervals above 1000 cps.

4.2.3.2 Test Results.

The distortion measurements for the three earphones tested are shown in Figures 26, 27 and 28.

4.2.4 Overload Test.

4.2.4.1 Description of Test.

Two earphone units were operated for eight hours with an electrical power input of 200 milliwatts at 1000 cps. All twenty service test units were operated for a period of five minutes with a power input of 200 milliwatts at 1000 cps.

4.2.4.2 Test Results.

The frequency response curves of the two units operated for eight hours as outlined above are shown in Figures 29 and 30. No changes in output level or frequency response were noted on the remaining units that were tested for five minutes.

4.3 Microphone Tests.

4.3.1 Response Test.

4.3.1.1 Description of Test.

The microphone was mounted 1/4 inch in from a calibrated sound source, as shown in Figure 31. The sound source had been previously calibrated using a Western Electric 640AA condenser microphone. A plot of the calibrated sound pressure at 1/4 inch from the sound source as a function of frequency is shown in Figure 32. The output of the microphone was continuously recorded using the mechanically coupled oscillator and recorder shown in Figure 31. From this measurement the corrected response of the microphone was plotted.

4.3.1.2 Test Results.

The corrected frequency response of all twenty microphones is shown in Figures 33 through 42.

4.3.2 Induced Voltage.

4.3.2.1 Description of Test.

The microphone was located centrally in a Helmholtz coil as manufactured by Welch Scientific Company. With a field of one oersted established at the center of the coil, the microphone was rotated until the maximum induced voltage reading across a 150 ohm resistor was obtained. This voltage reading was recorded for all twenty units.

4.3.2.2 Test Results.

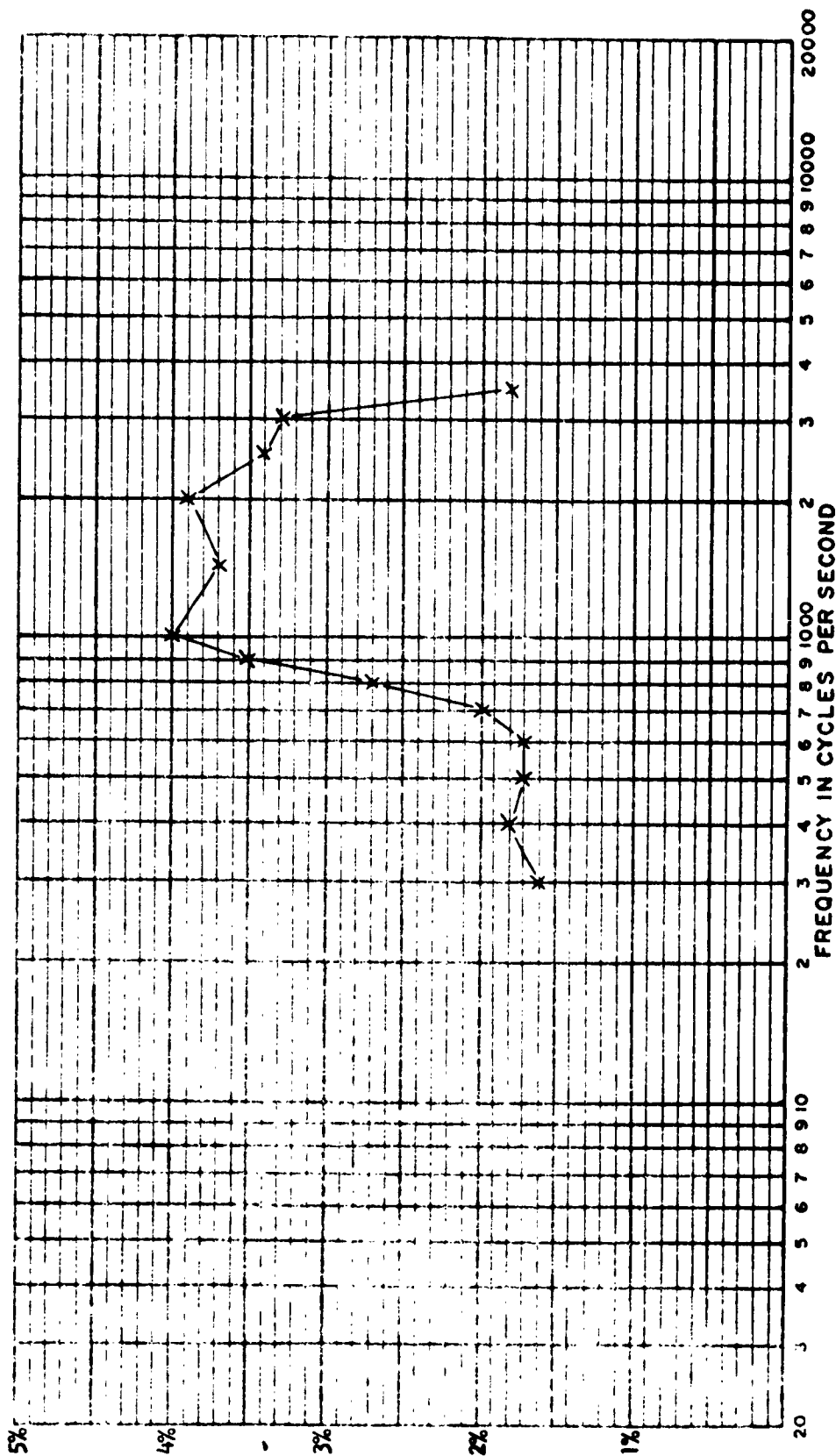
The induced voltage in microvolts output in a magnetic field of one oersted is shown in Figure 43. Since the minimum sensitivity of the microphone at 1000 cps is 45 microvolts/dyne/cm² loaded 16 db above this value would be 137 microvolts. None of the microphones measured exceeded this value.

TEST RESULTS

TEST Earphone Distortion

SPEC. REF. _____

DATE 7-5-62



COMMENTS _____

UNIT NO. 3

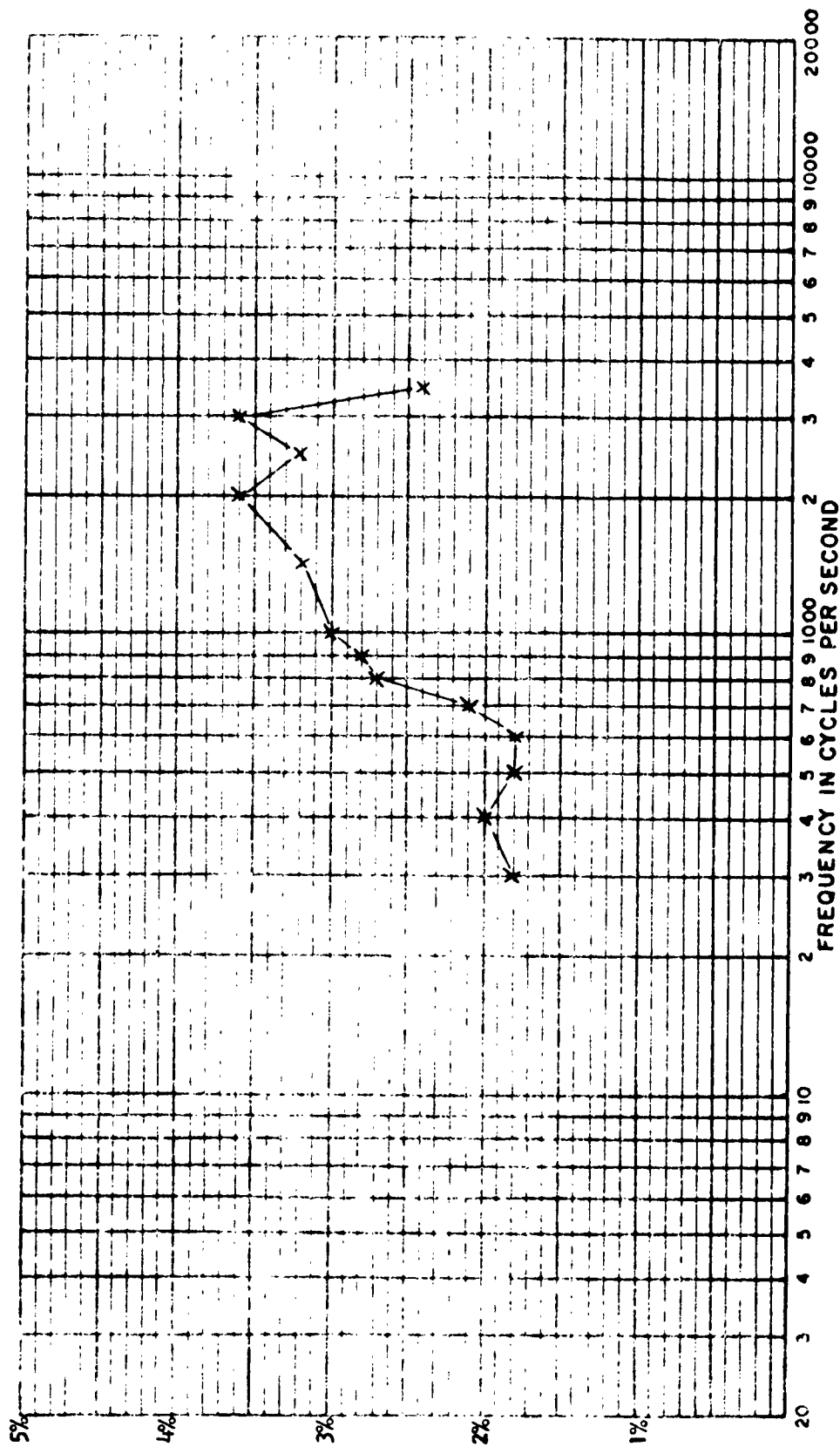
FIGURE 26.

TEST RESULTS

TEST Earphone Distortion

SPEC. REF. _____

DATE 7-5-62



COMMENTS UNIT NO. 11

FIGURE 27.

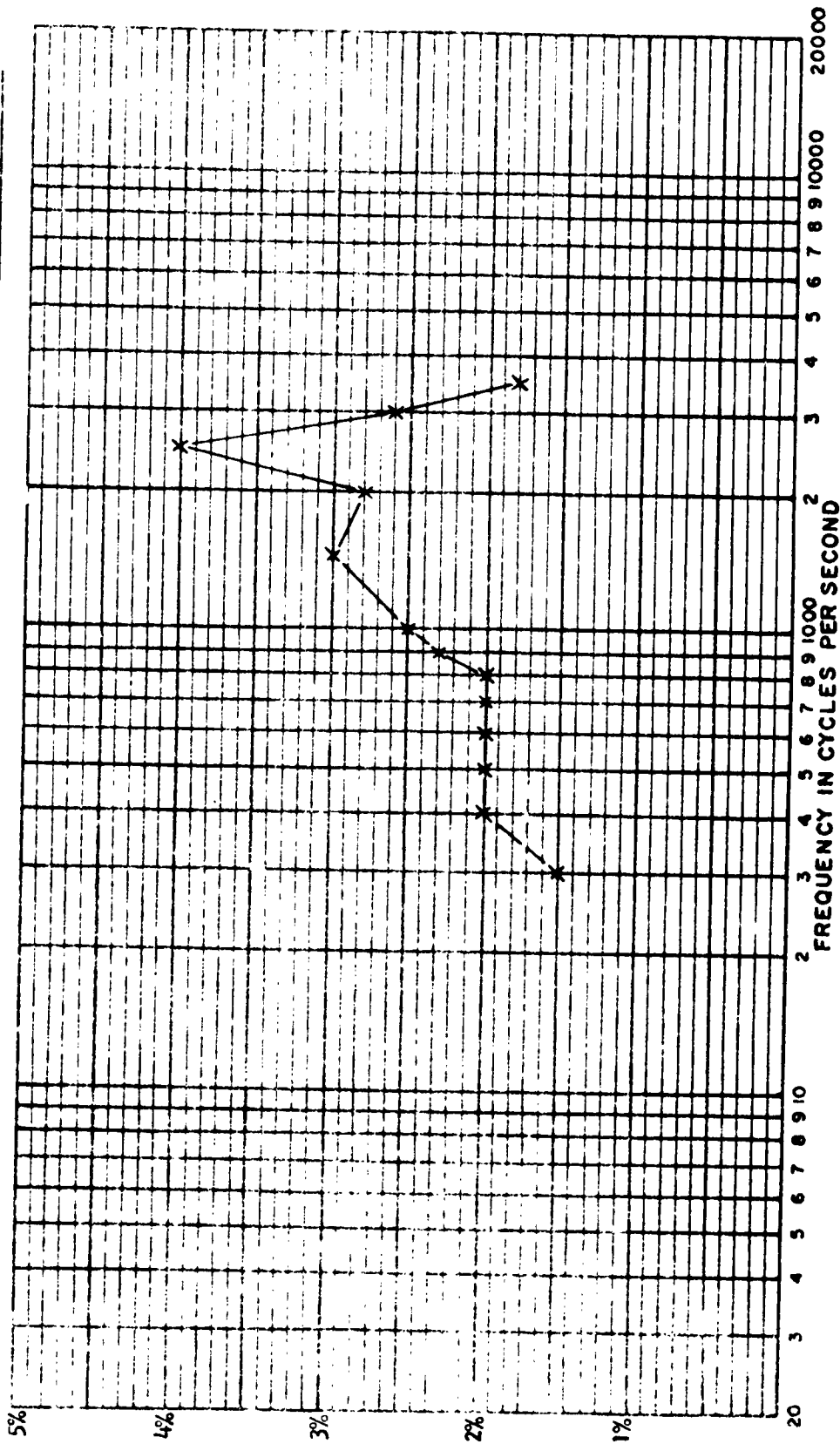
TEST RESULTS

TEST Earphone Distortion

SPEC. REF. SCL-4195

Par. 4.4.3

DATE 7-5-62



COMMENTS UNIT NO. 20

FIGURE 28.

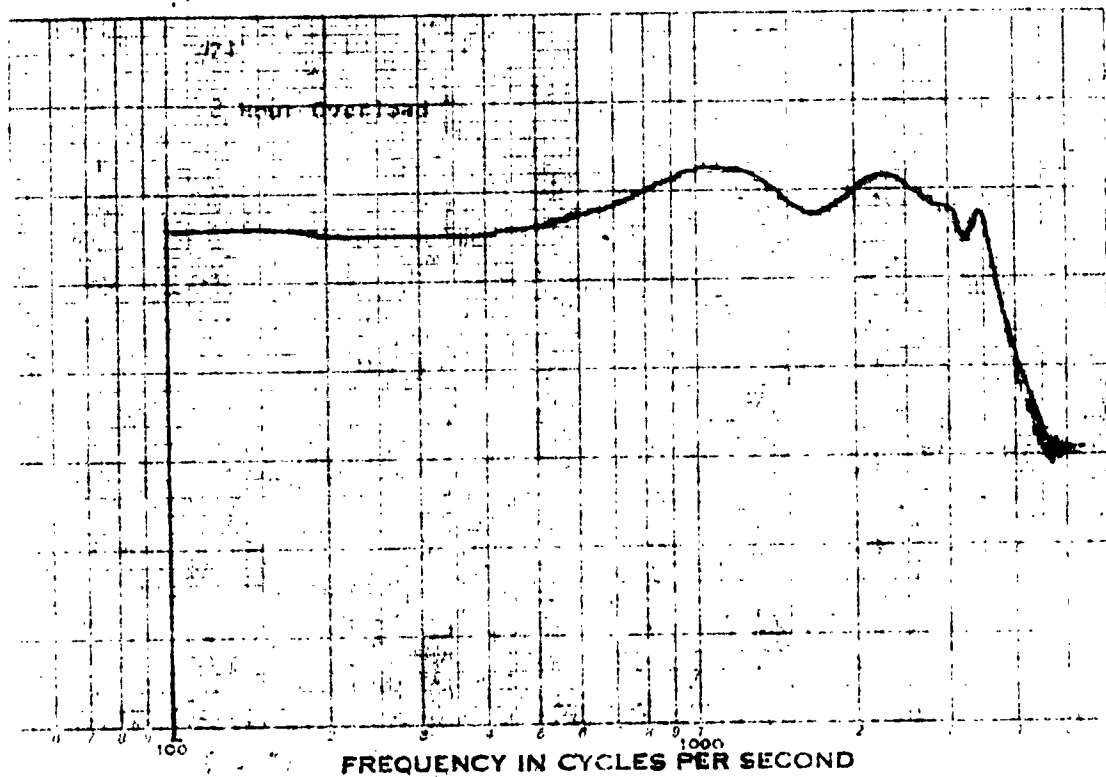


FIGURE 29.

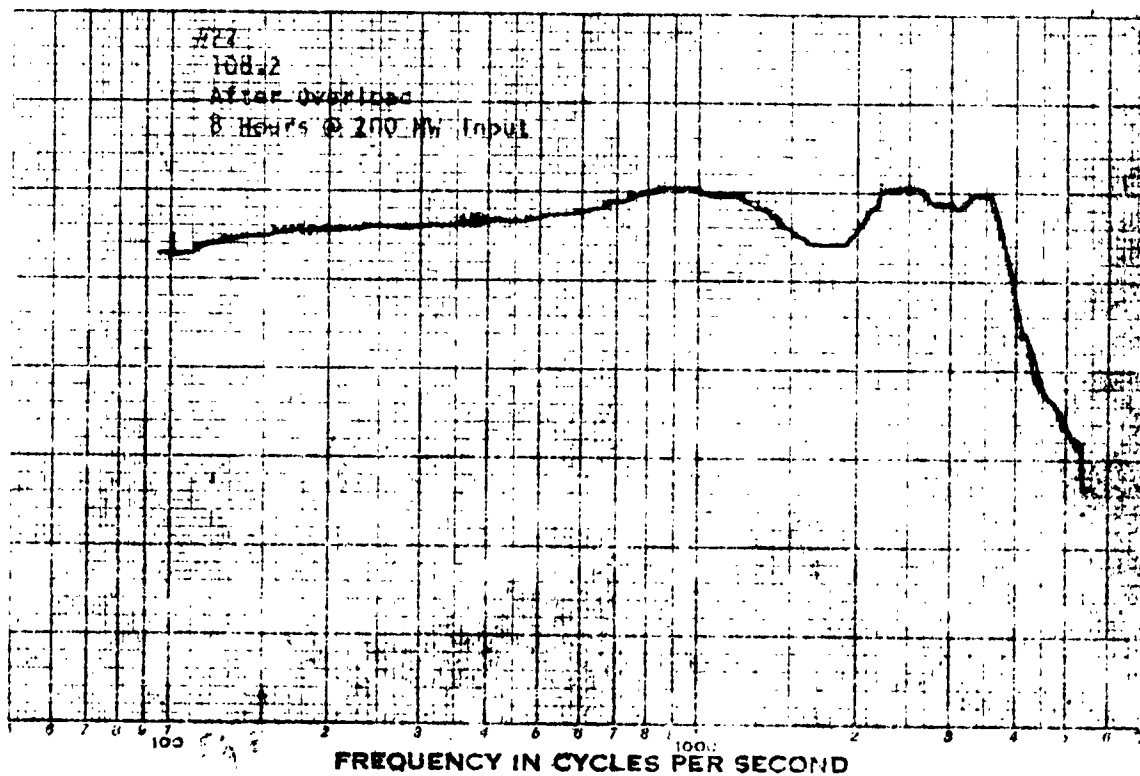


FIGURE 30.

Handset Under Test

Close Sound Source

150a

Ballantine Laboratories
Electronic Voltmeter
Model S/2
Serial No. 27956

(Rack)

$\frac{1}{4}$ in.

• • •
• • •

Pre-Amplifier

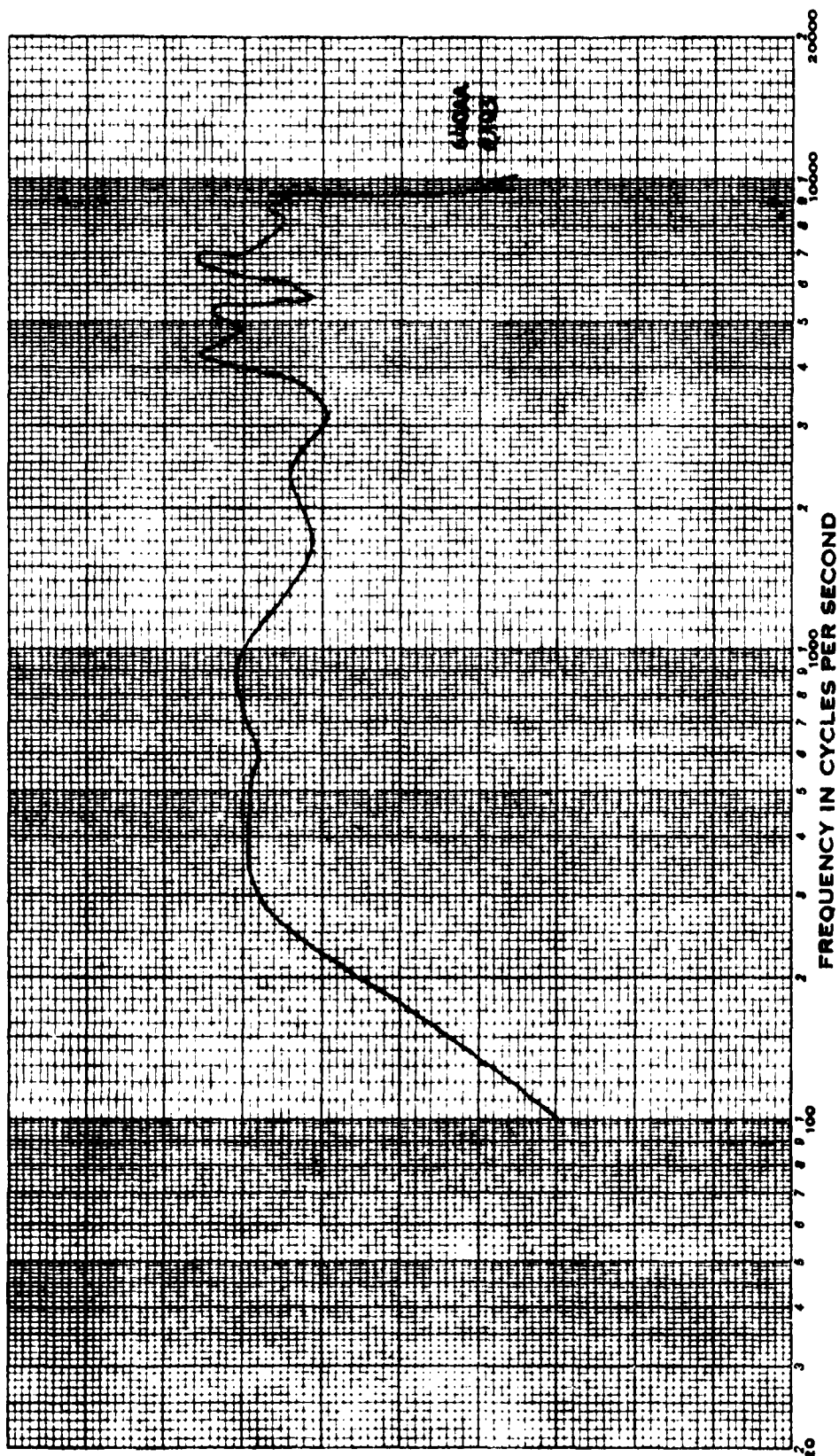
Sound Apparatus
Company
Model FR Recorder
Serial No. 1035

G.R. Oscillator
Type No. 1304A
Serial No. 504

E.V. Amplifier
Model A-30

FIGURE 31.

MODEL Artificial Mouth
 FOR Microphone Lab
 Z OHMS. TRANS. DB/DIV. 1/2
 RECORD DATE 7-18-62
 SOUND PRESSURE 114 DB 2
 REFERENCE: 0 DB= 0002 dynes/cm²
 MICROPHONE PLACEMENT 1/4"
 SPECIAL NOTES Driver Voltage for 114 db at
1 KC = .94 volts



Electro-Voice

RUN BY _____ CHECKED BY _____

FIGURE 32.

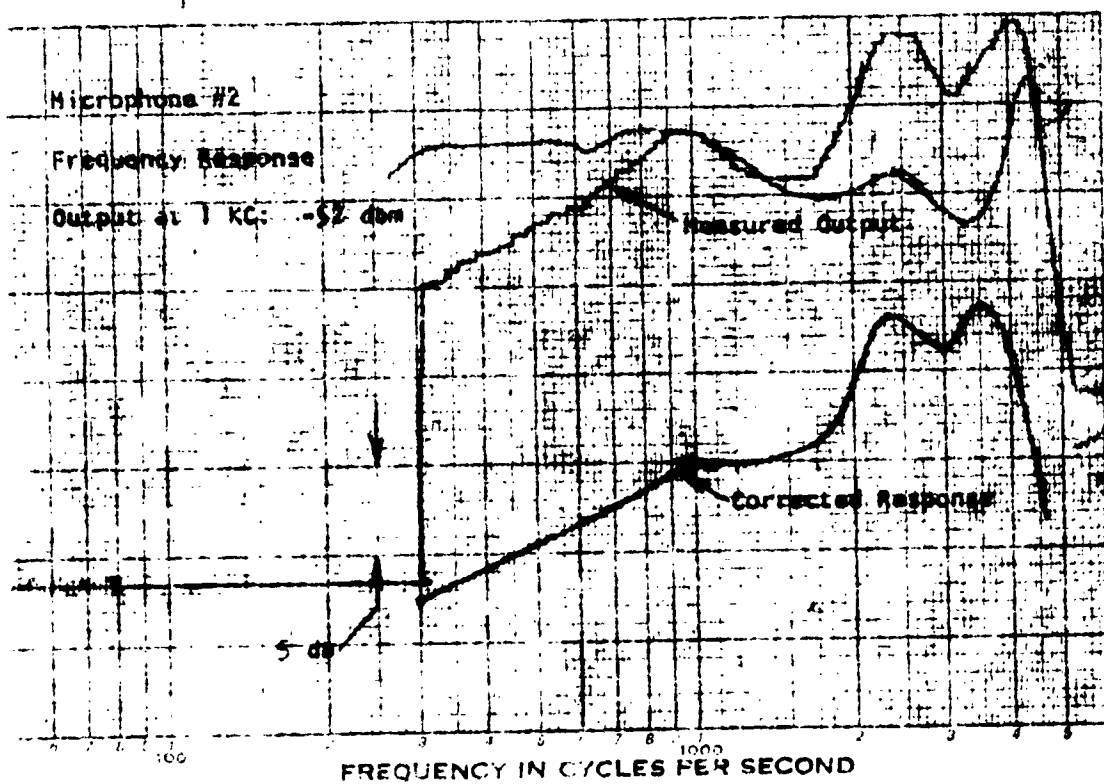
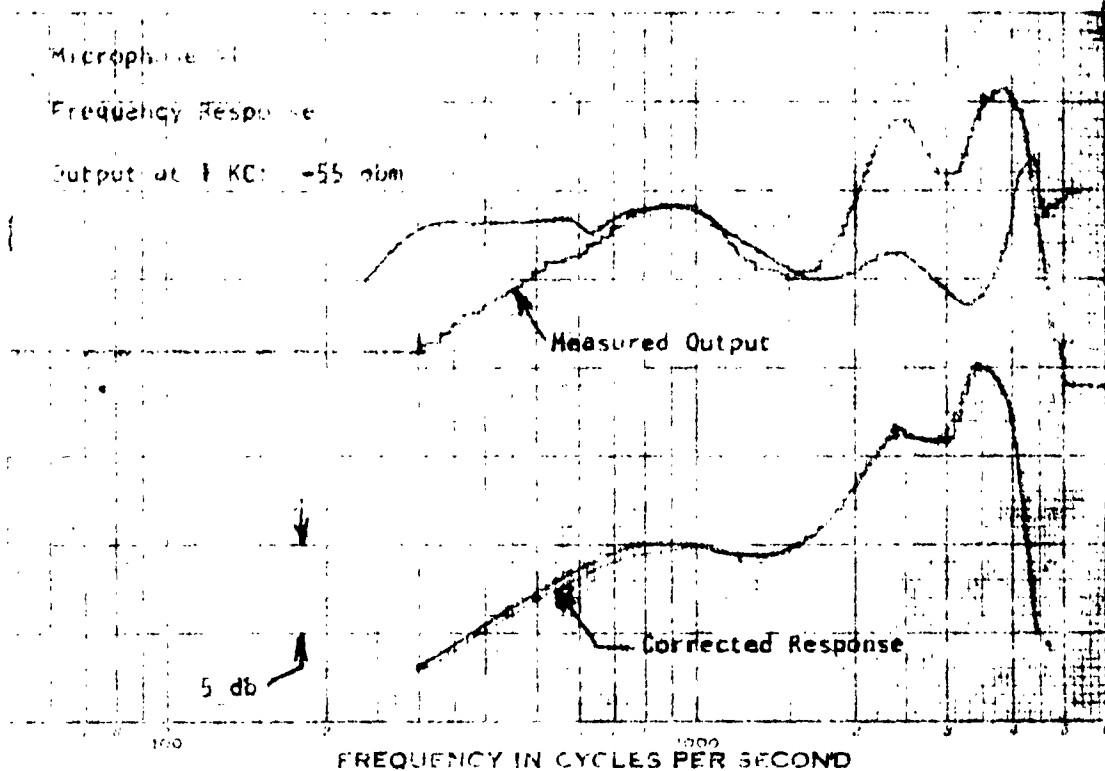


FIGURE 33.

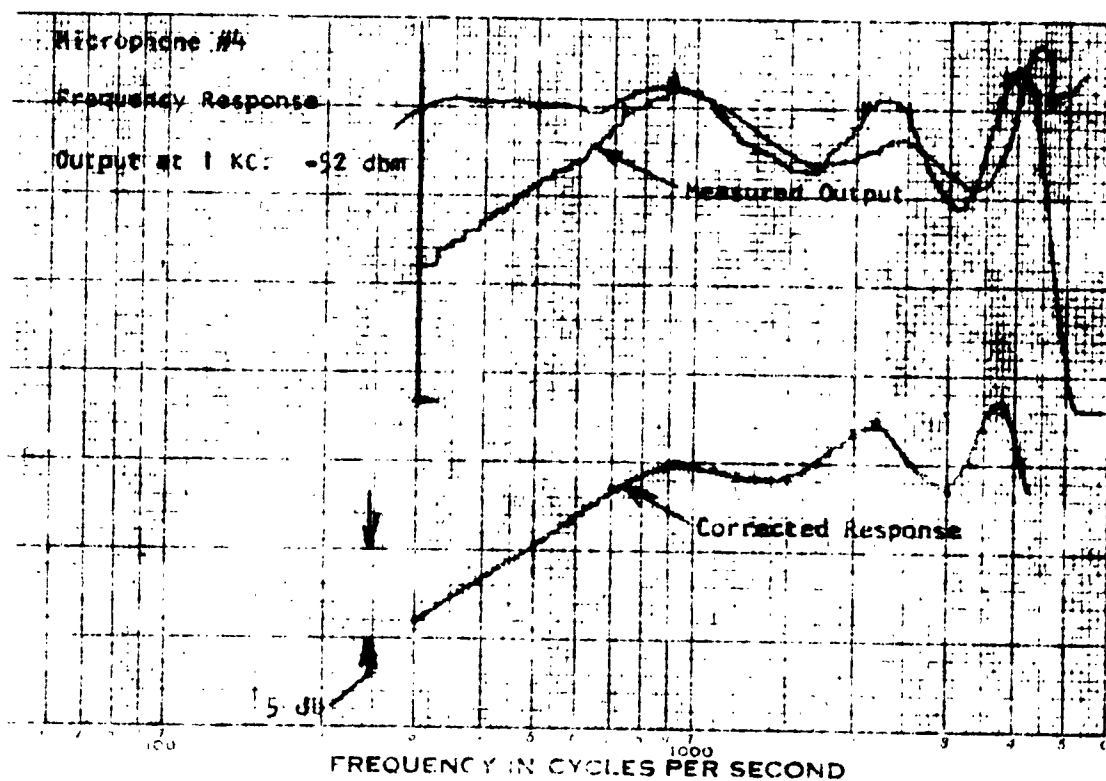
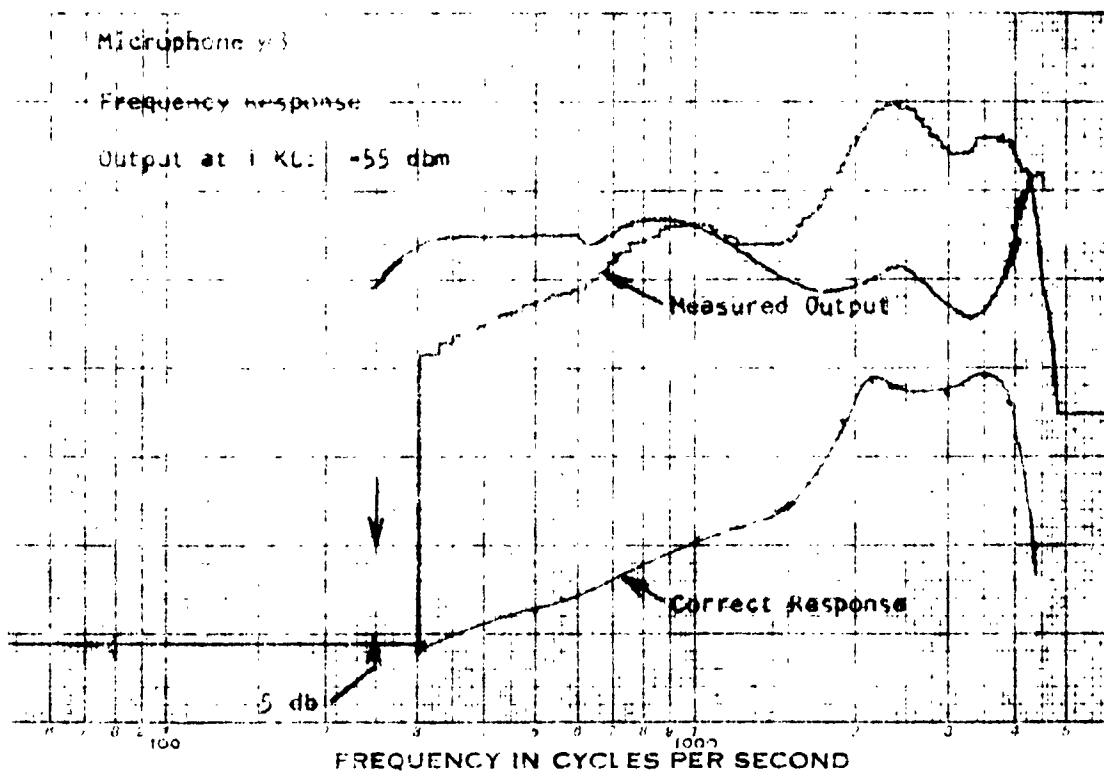


FIGURE 34.

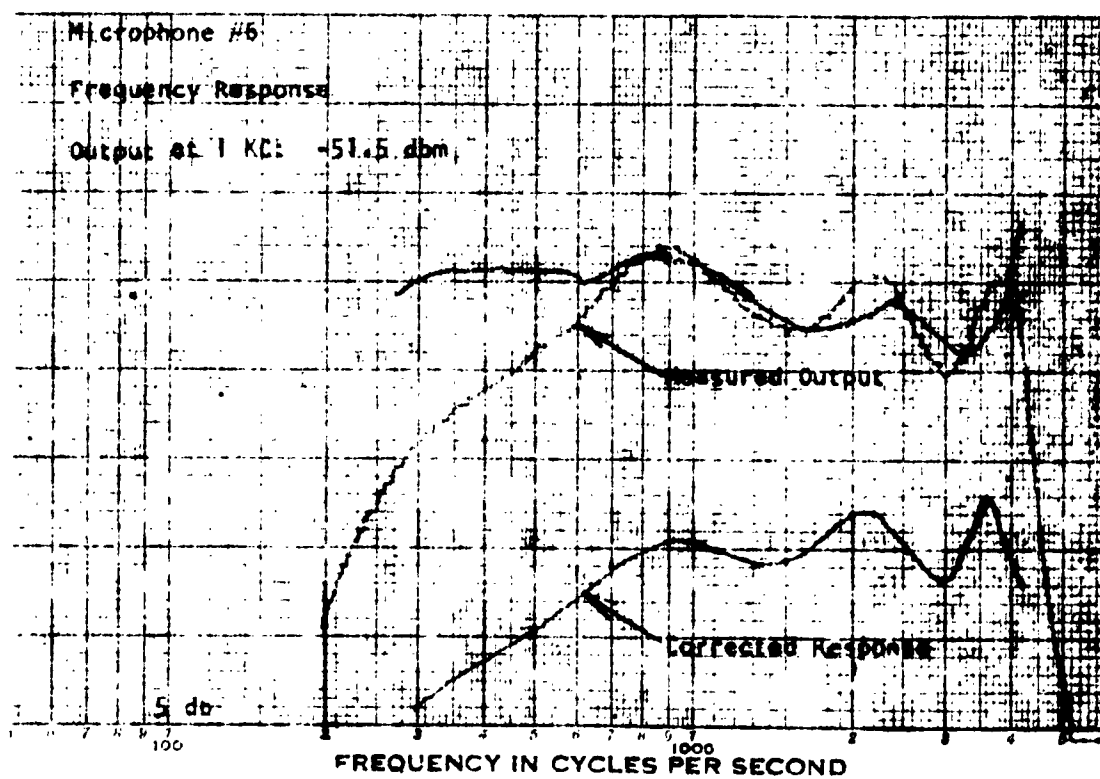
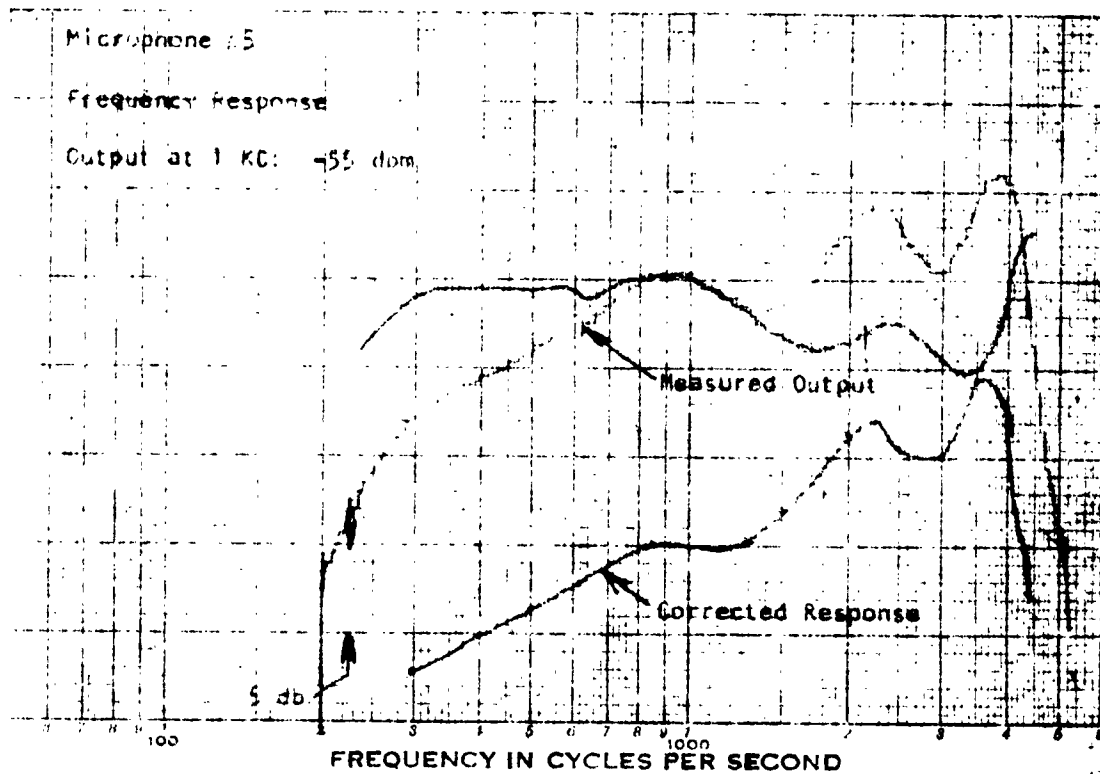


FIGURE 35.

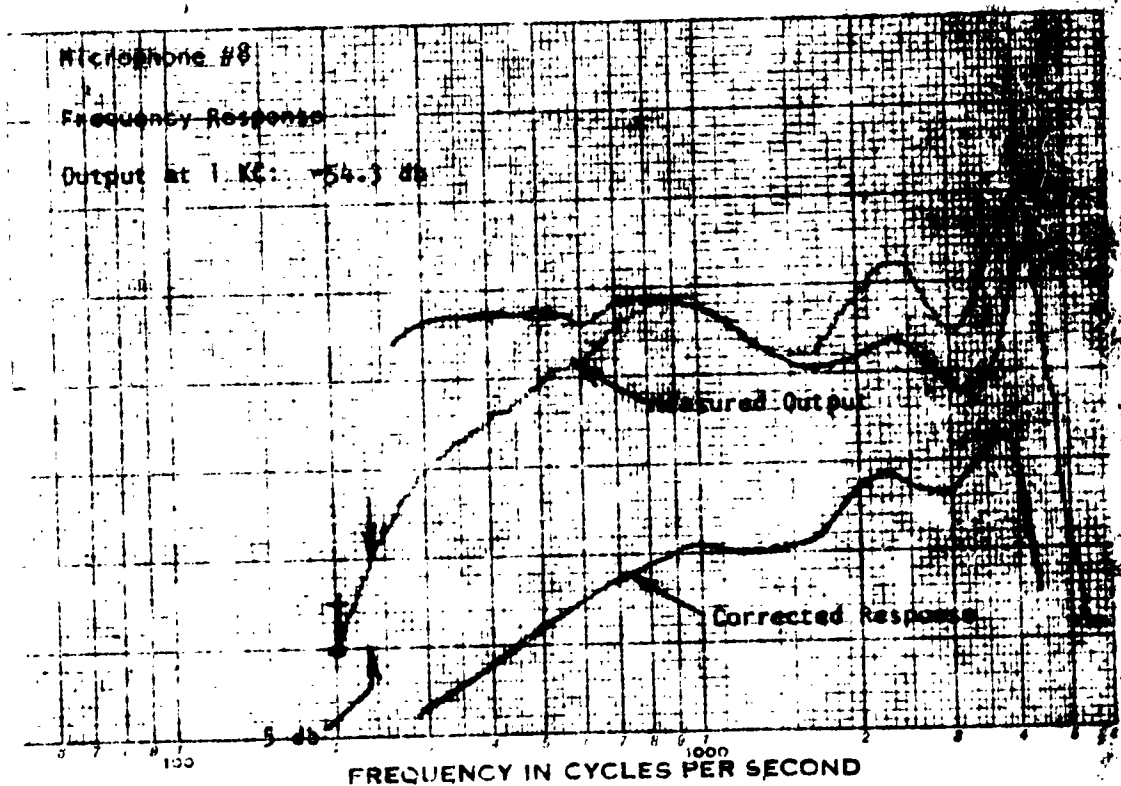
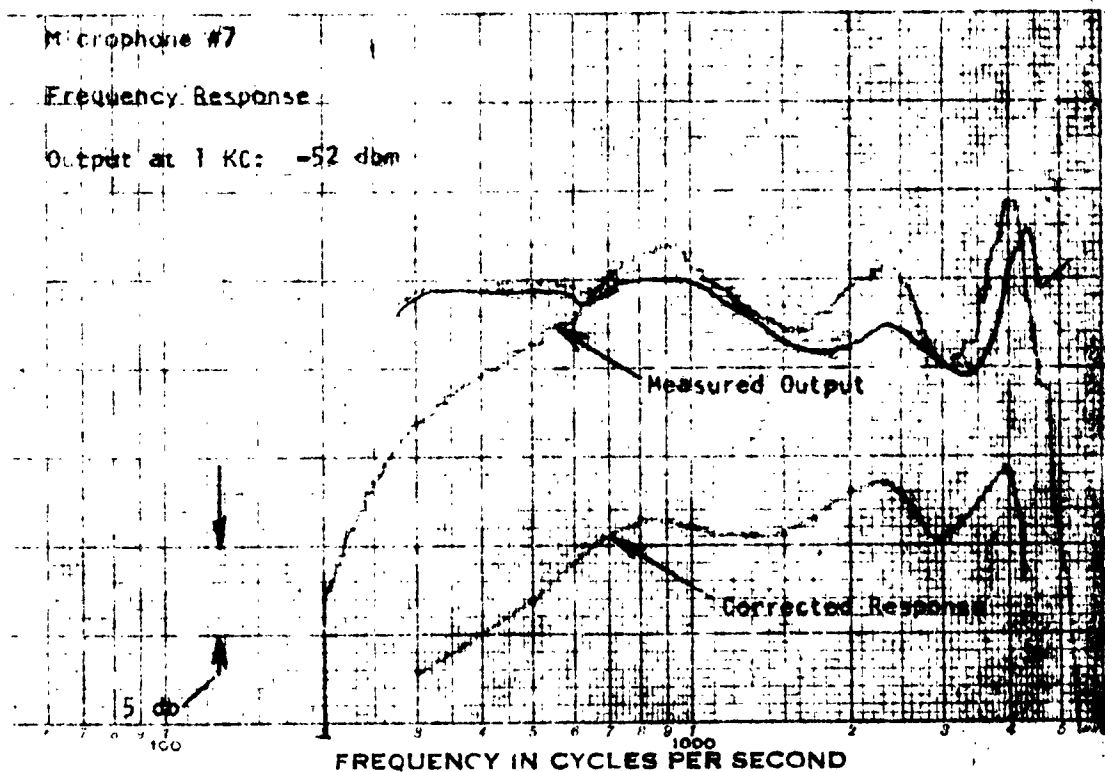


FIGURE 36.

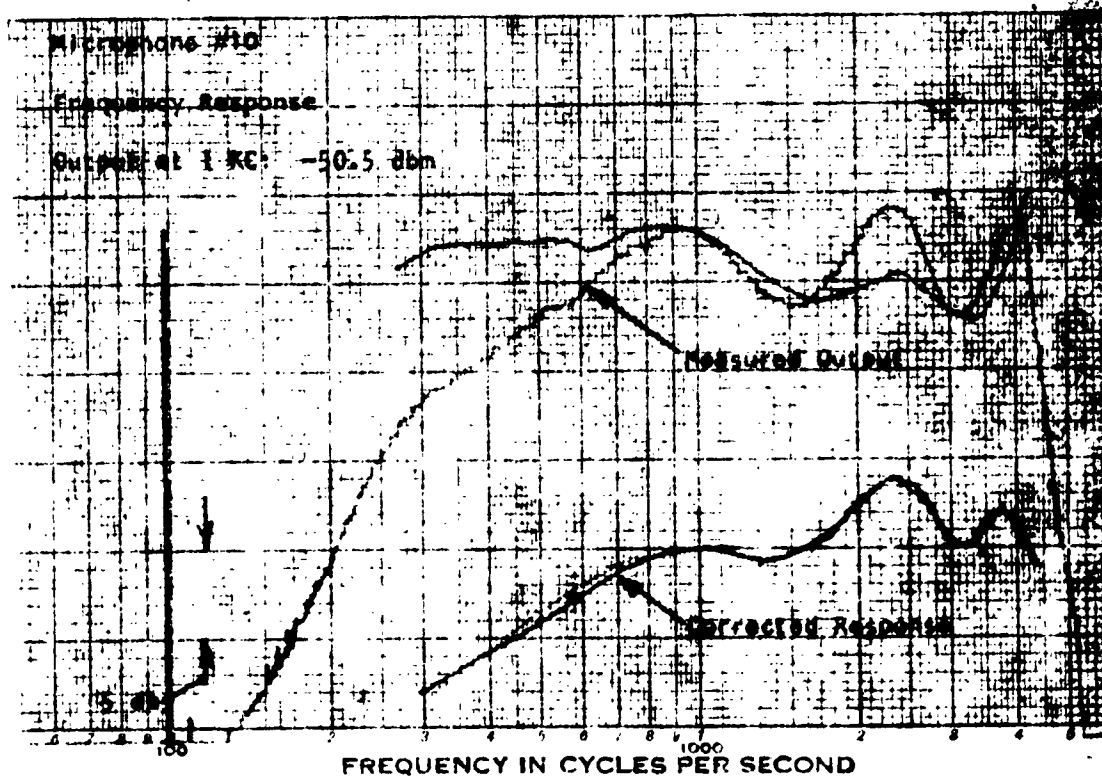
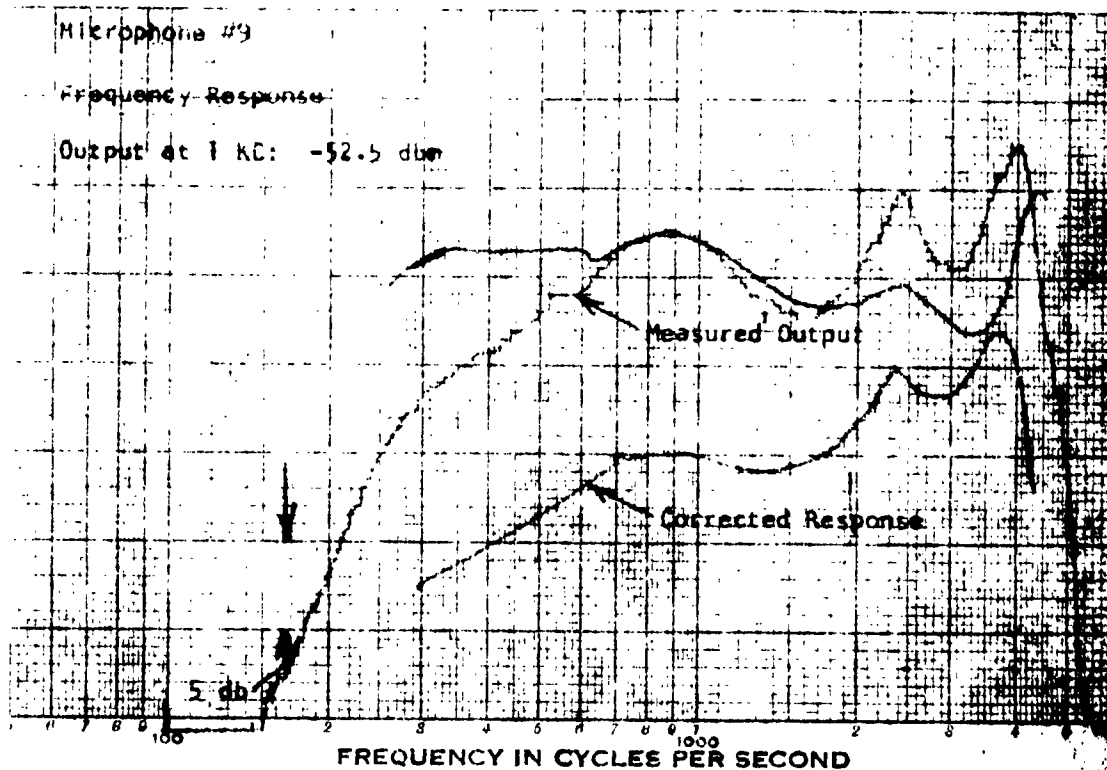


FIGURE 37.

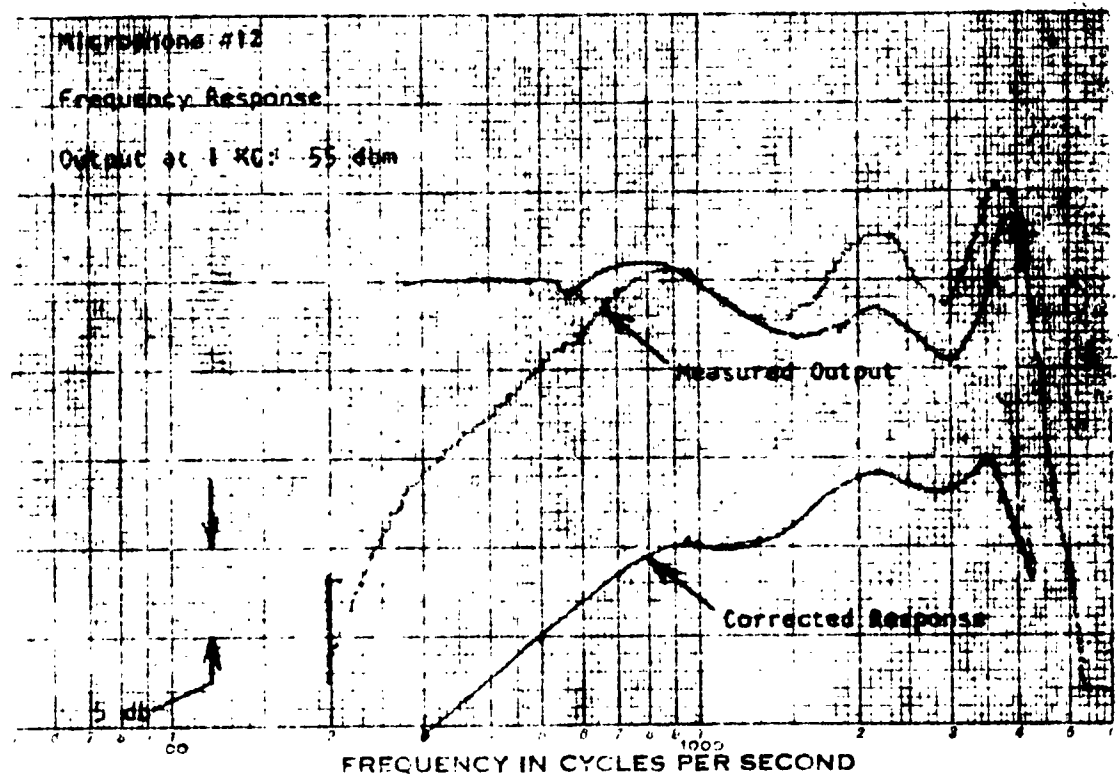
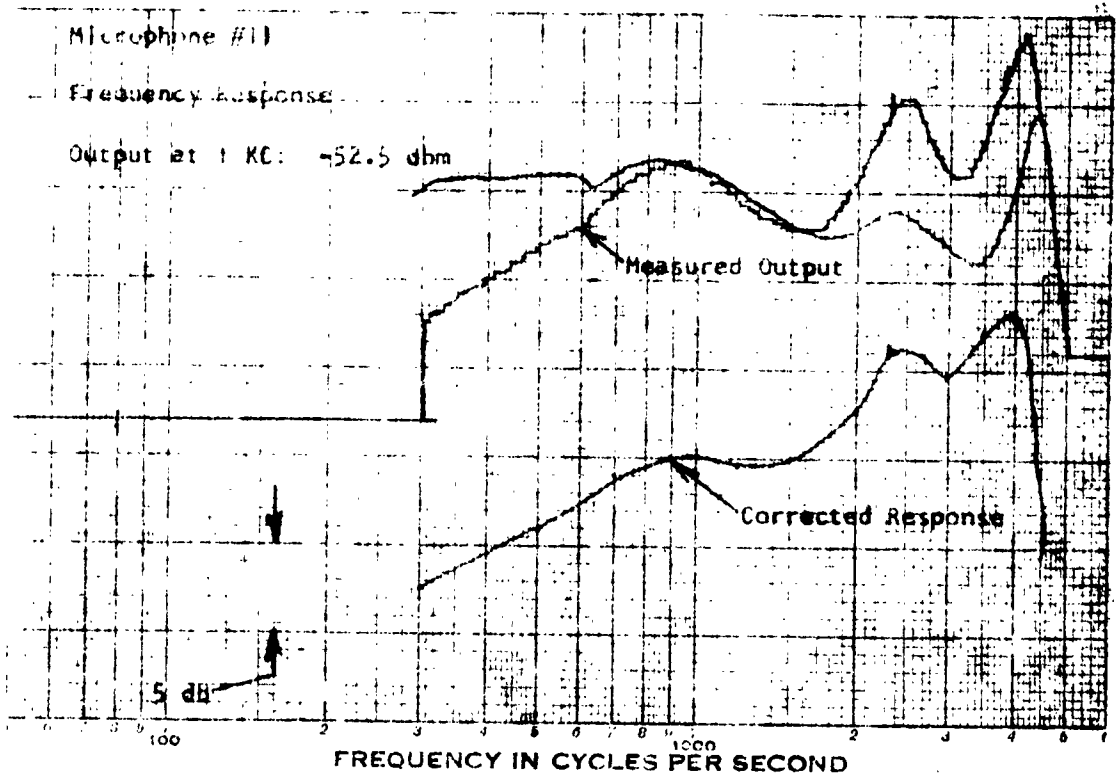


FIGURE 38.

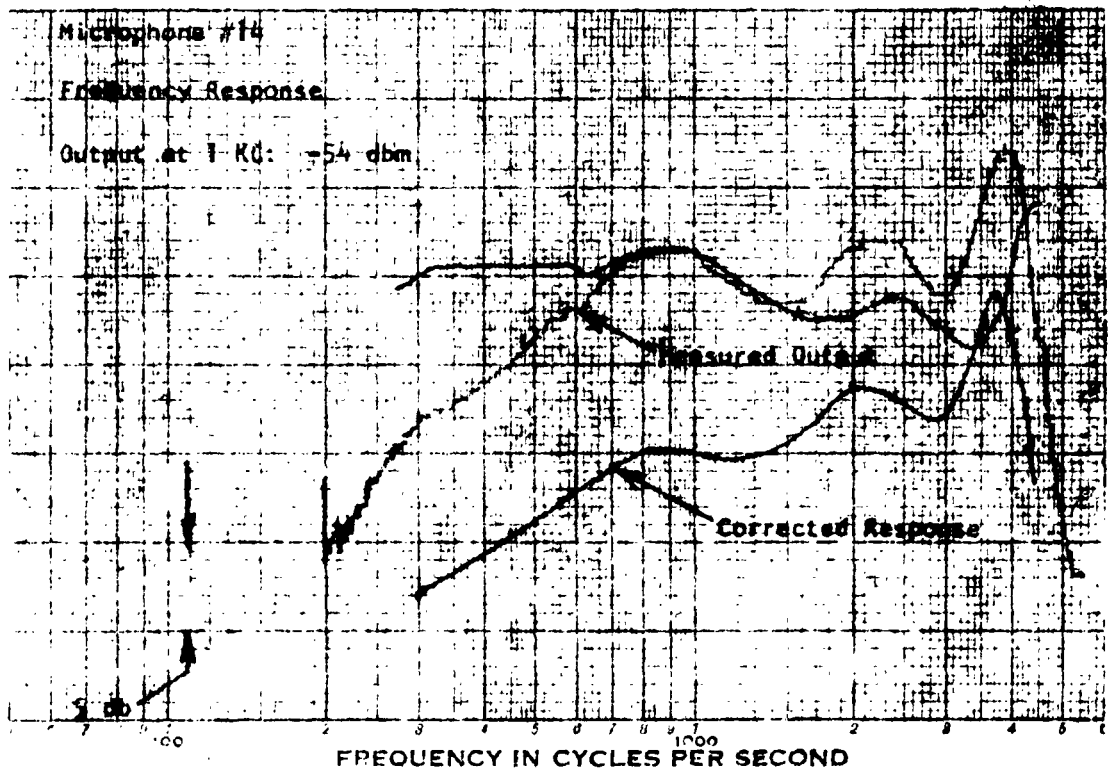
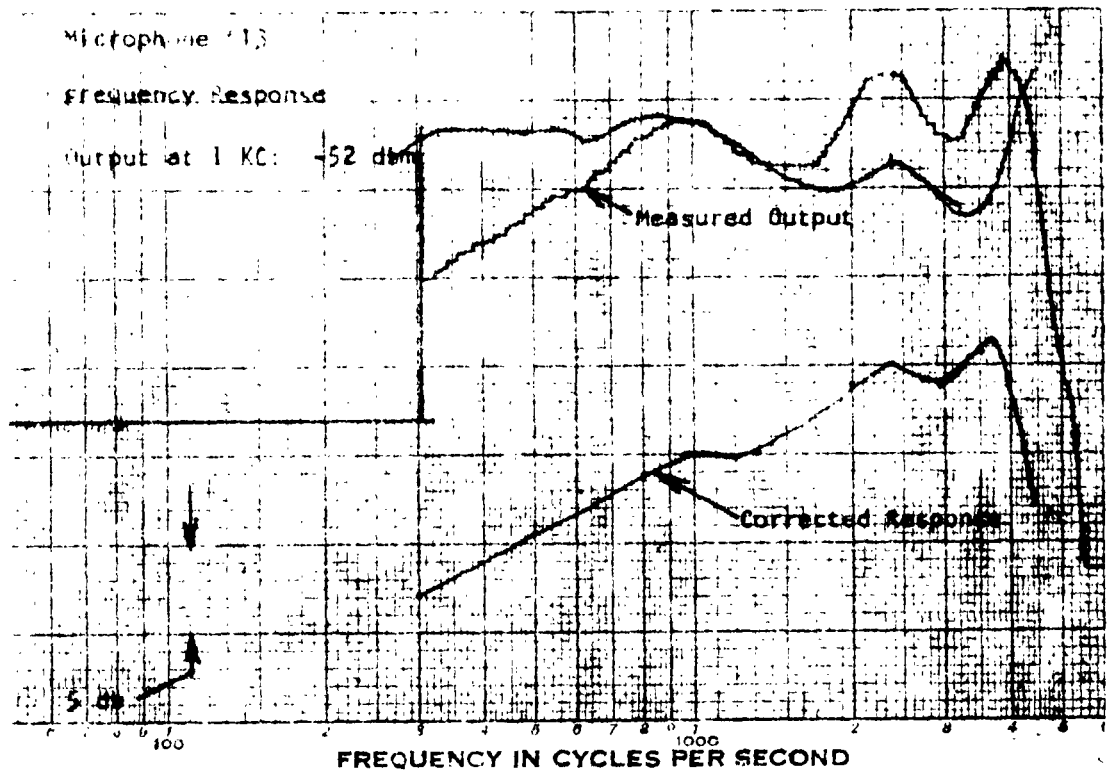


FIGURE 39.

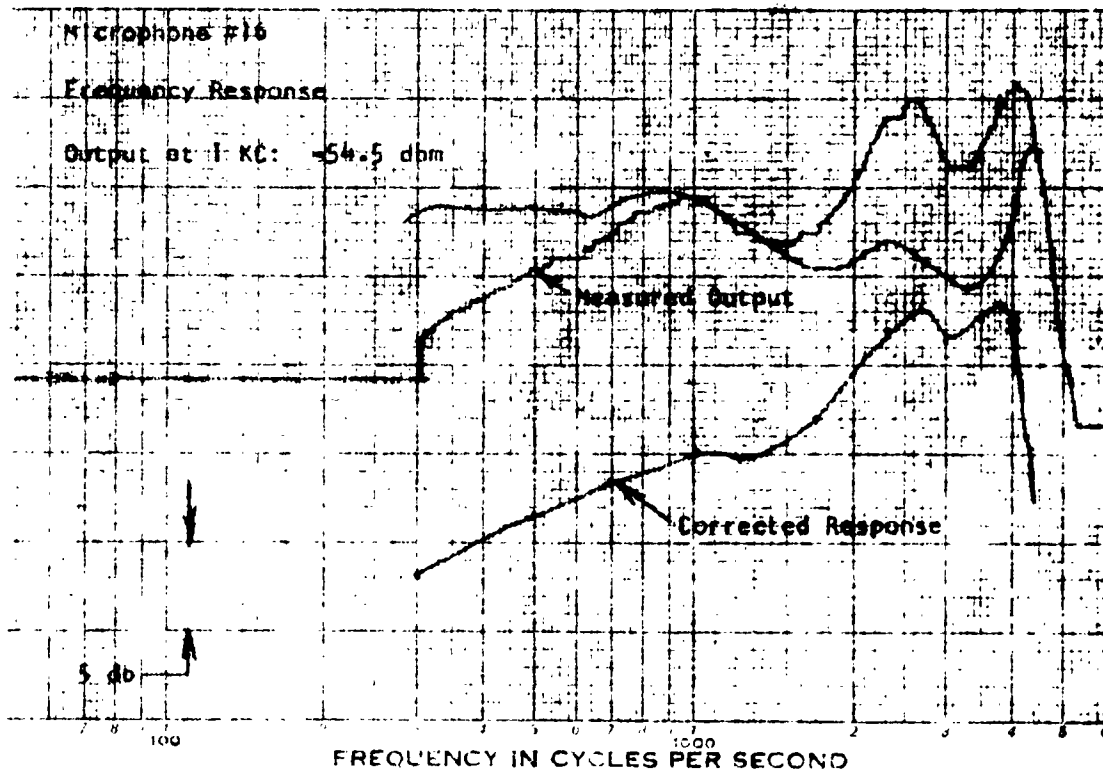
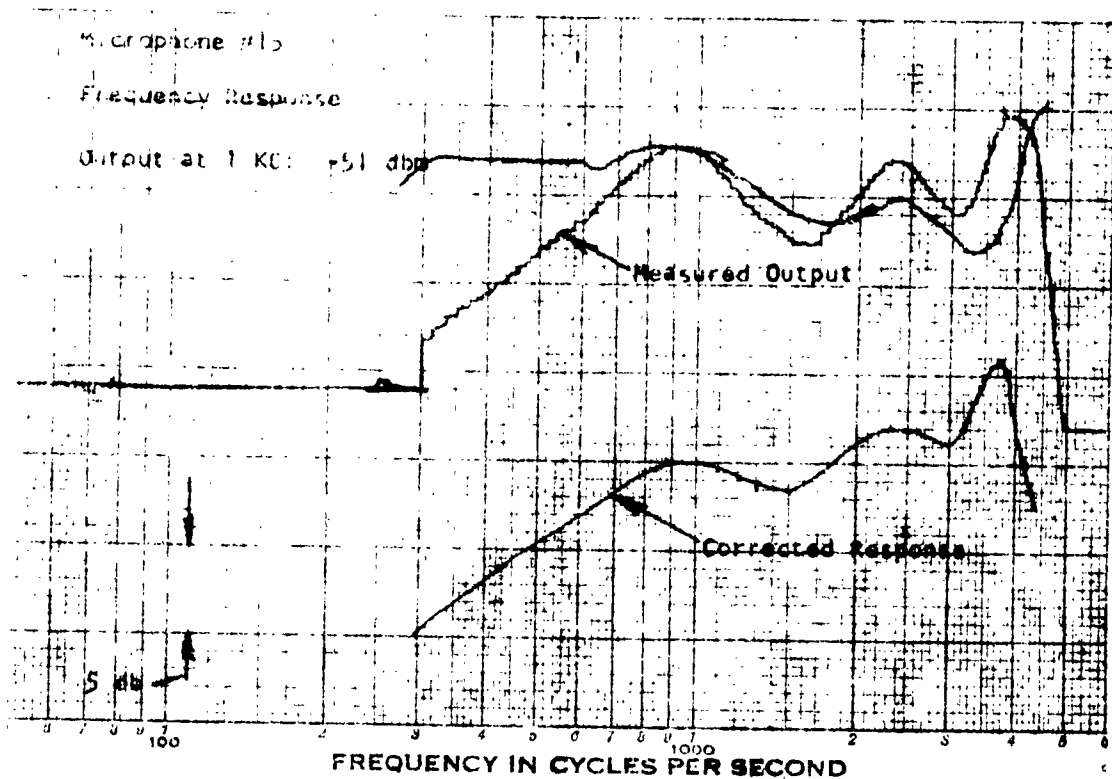


FIGURE 40.

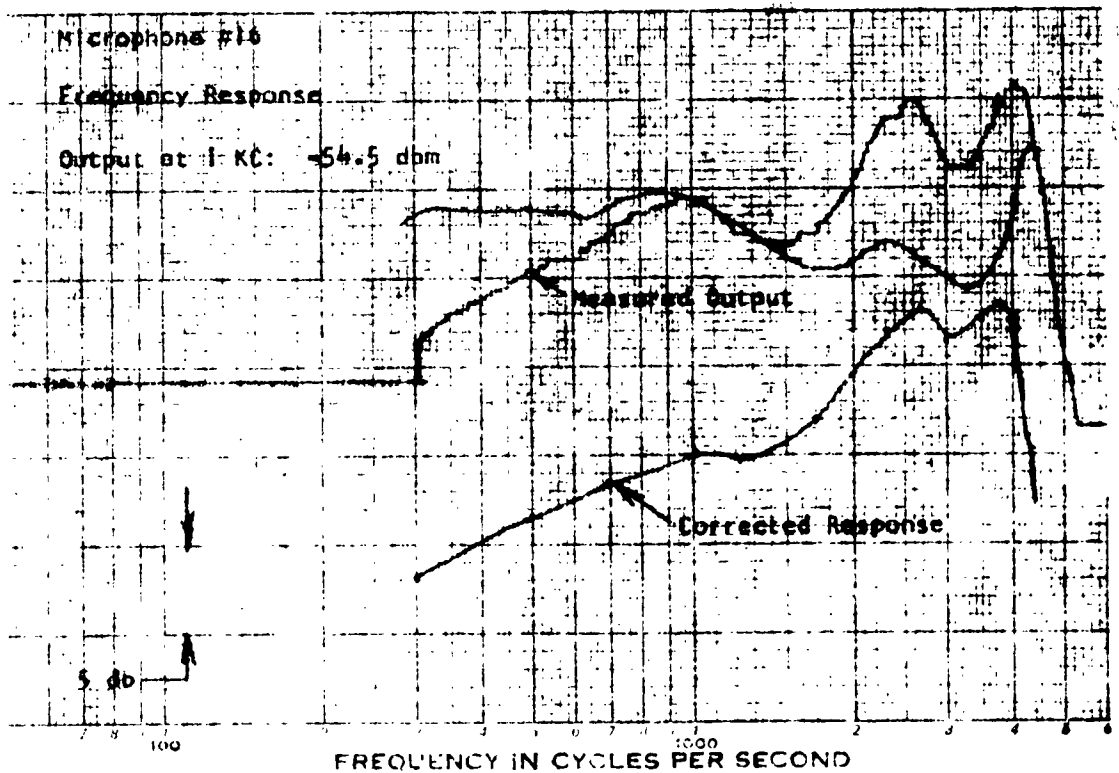
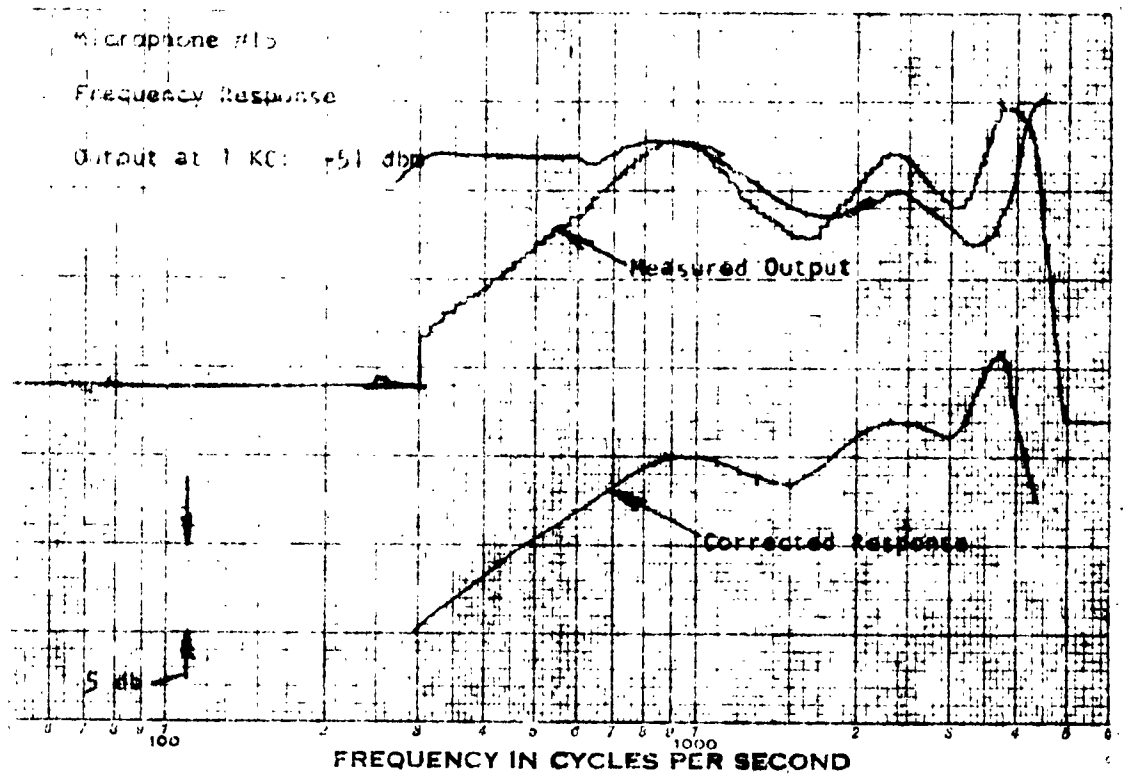


FIGURE 40.

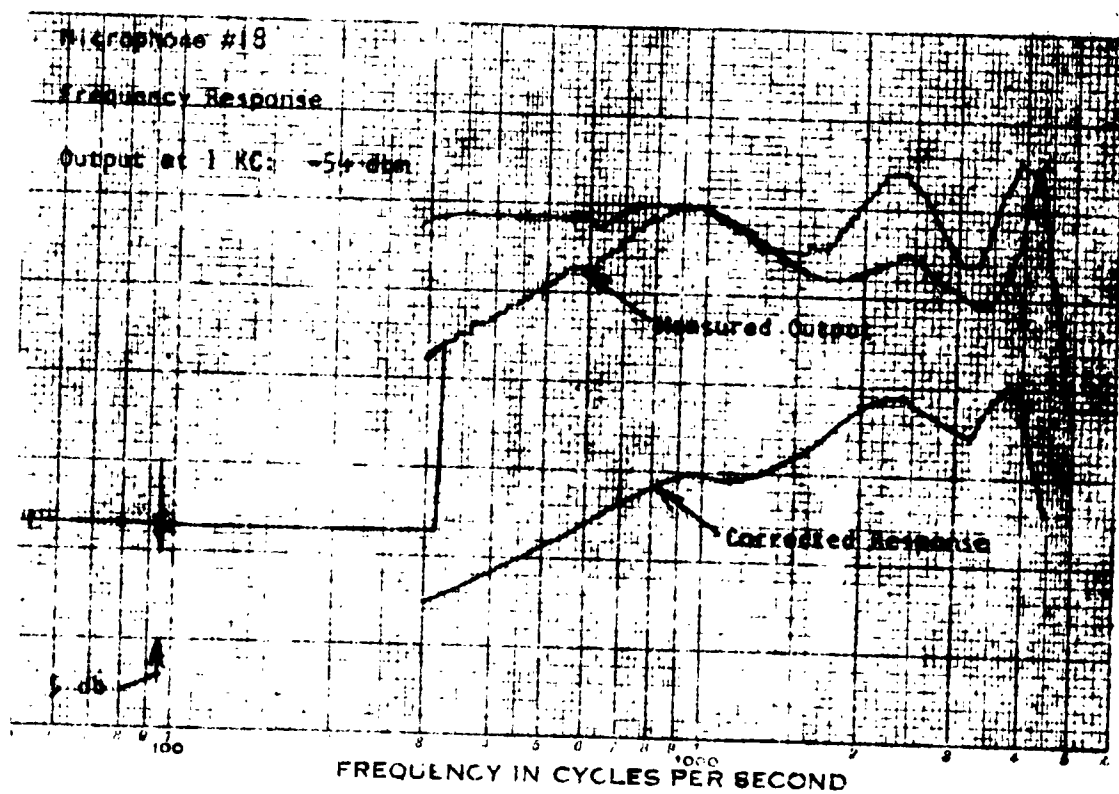
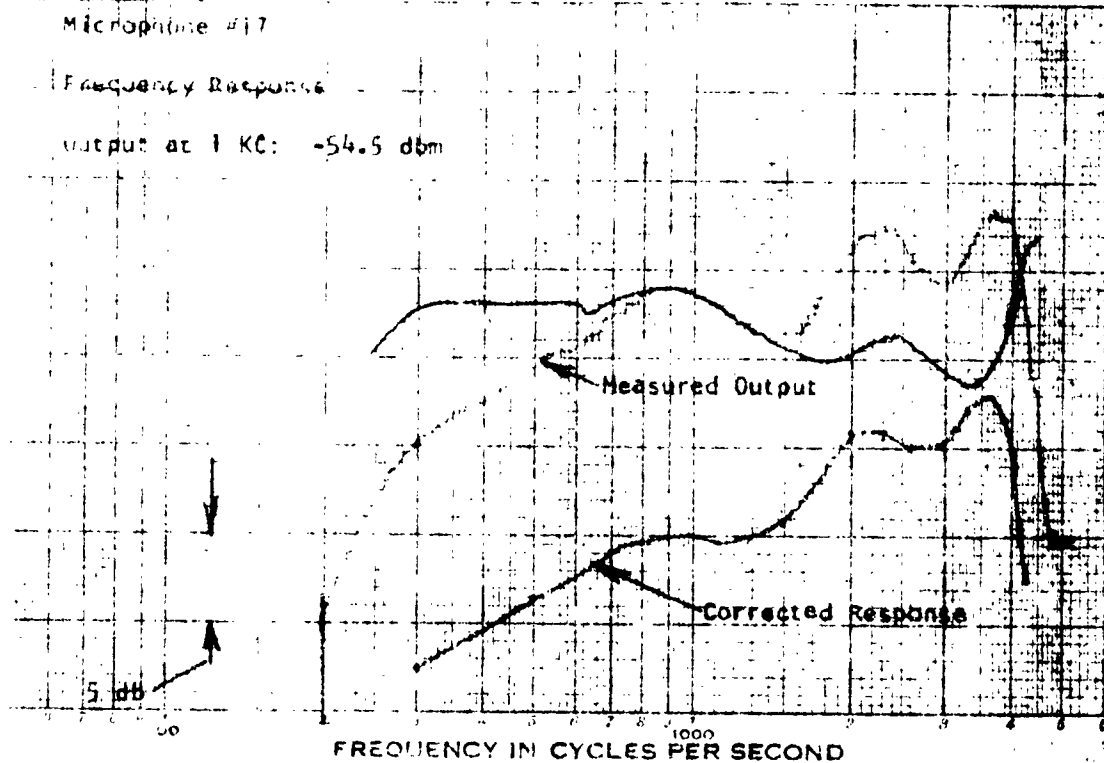


FIGURE 41.

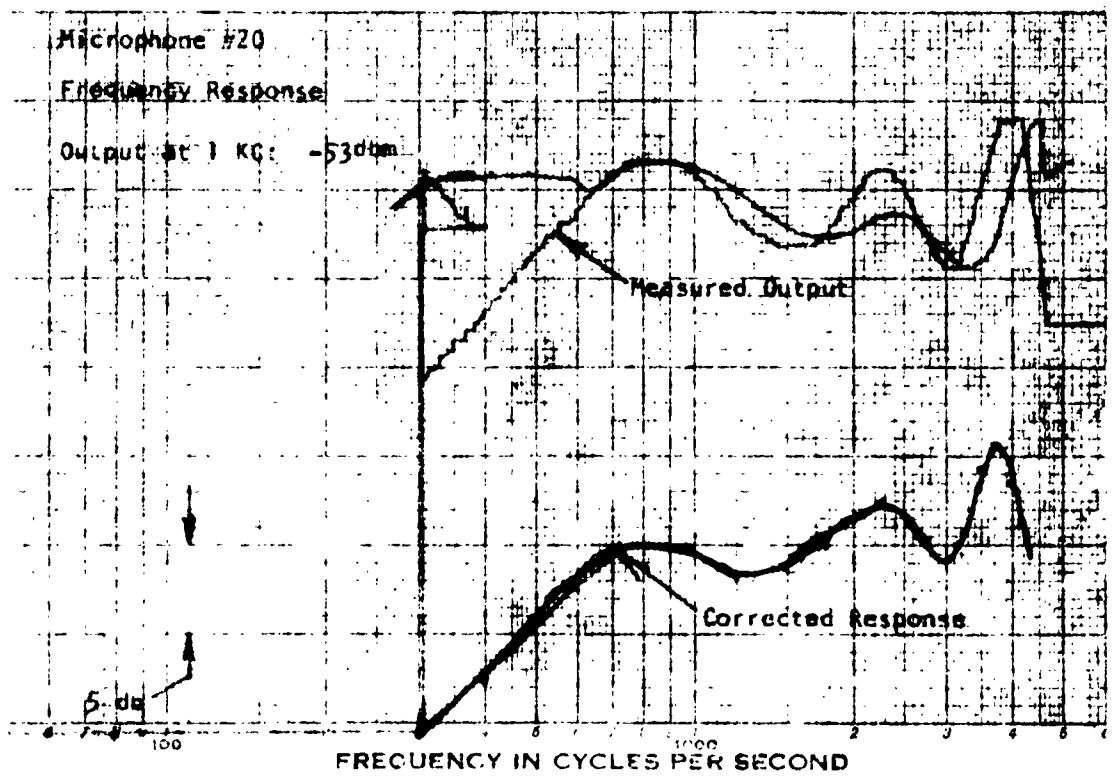
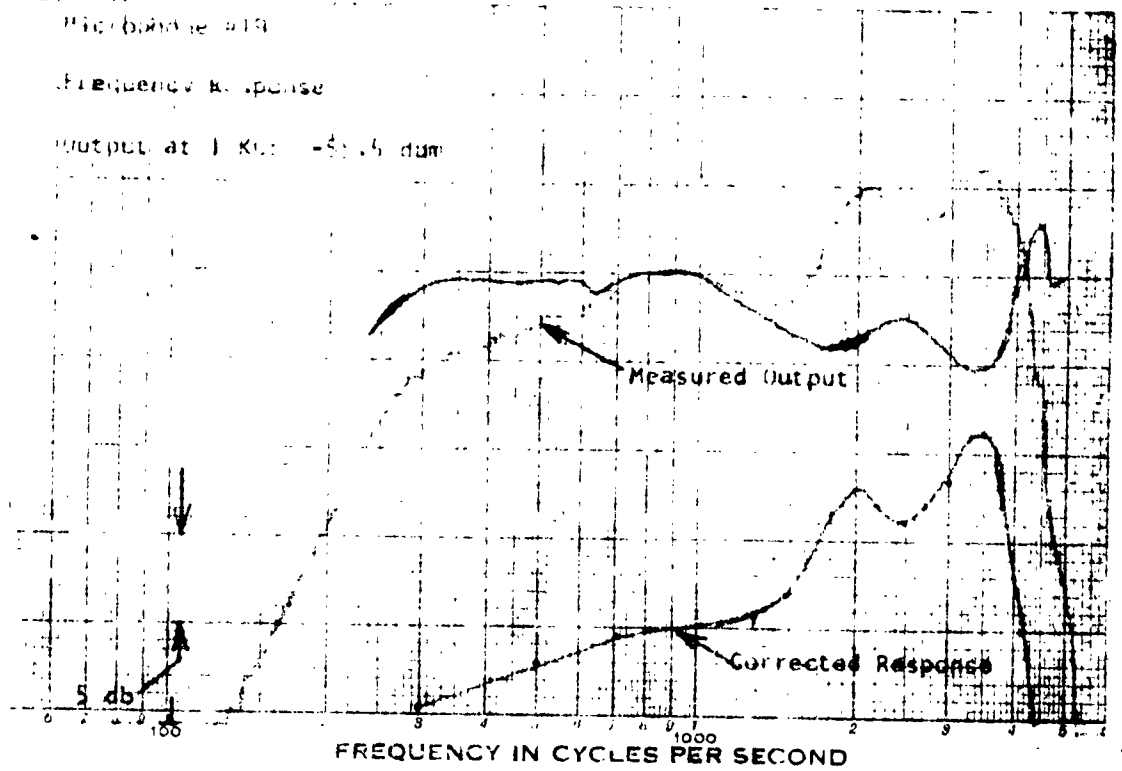


FIGURE 42.

UNIT NO.	$V_{out}/Oersted (\mu v)$
1	130
2	105
3	125
4	110
5	135
6	110
7	115
8	130
9	135
10	130
11	110
12	135
13	125
14	115
15	105
16	120
17	135
18	130
19	135
20	135
21	115

FIGURE 43.

4.3.3 Distortion Test.

4.3.3.1 Description of Test.

The microphone was connected as shown in Figure 31, except that the microphone output was connected to a Hewlett Packard Model 330B Distortion Analyzer. Distortion measurements were made on three units at 100 cps intervals below 1000 cps and at 500 cps intervals above 1000 cps.

4.3.3.2 Test Results.

The results of the distortion measurements described above are shown for the three microphones tested in Figures 44, 45 and 46.

4.4 Dielectric Strength and Insulation Resistance Test.

4.4.1 Description of Test.

A five hundred volt/rms, 60 cycle, A.C. voltage was applied between the earphone and microphone terminals on the U-182/U connector and the switch plate. The insulation resistance between these connections was also measured.

4.4.2 Test Results.

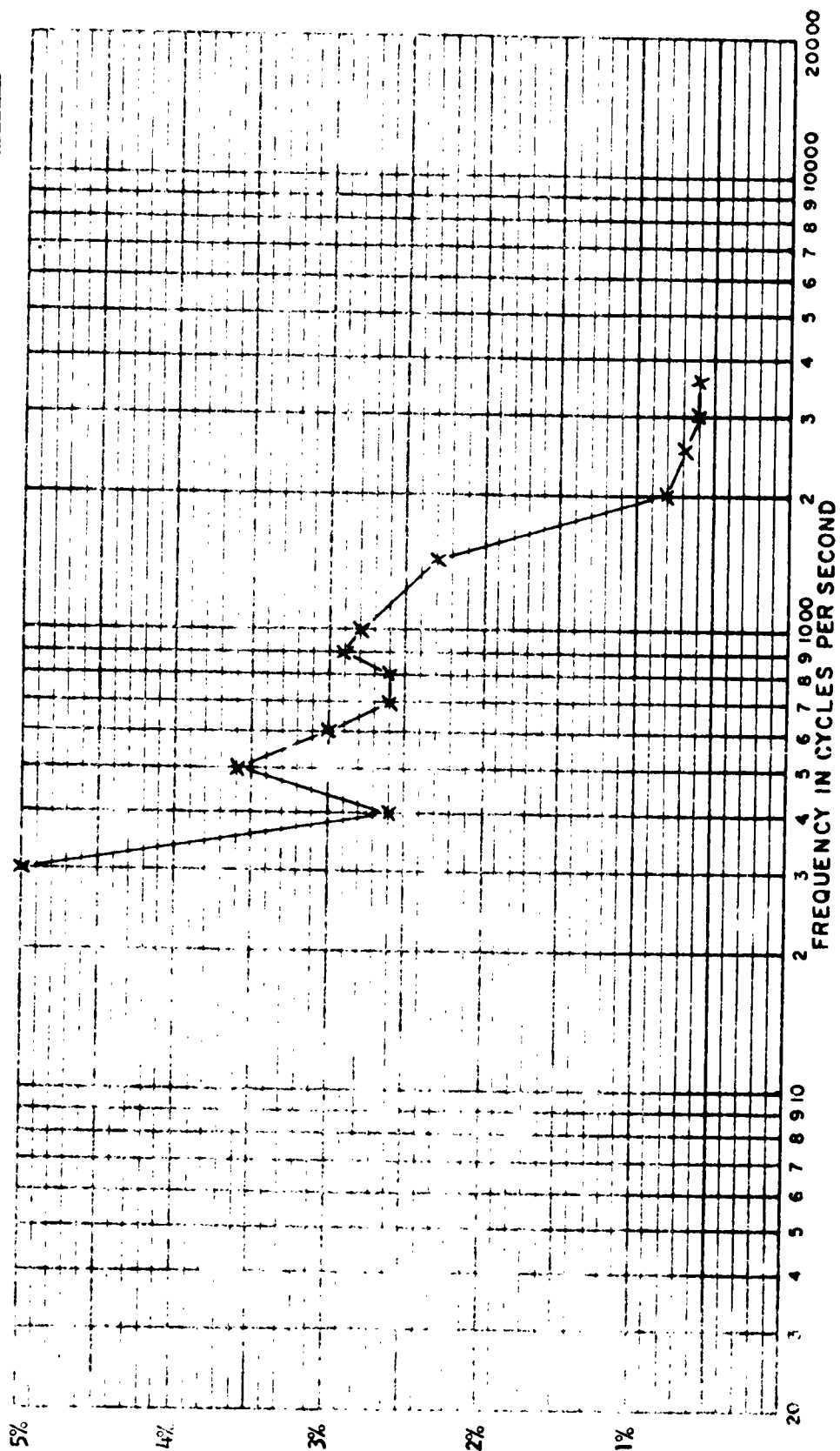
No breakdown occurred. The insulation resistance did not measure below one megohm.

TEST RESULTS

TEST Microphone Distortion

SPEC. REF.

DATE 7-5-62



COMMENTS UNIT NO. 3

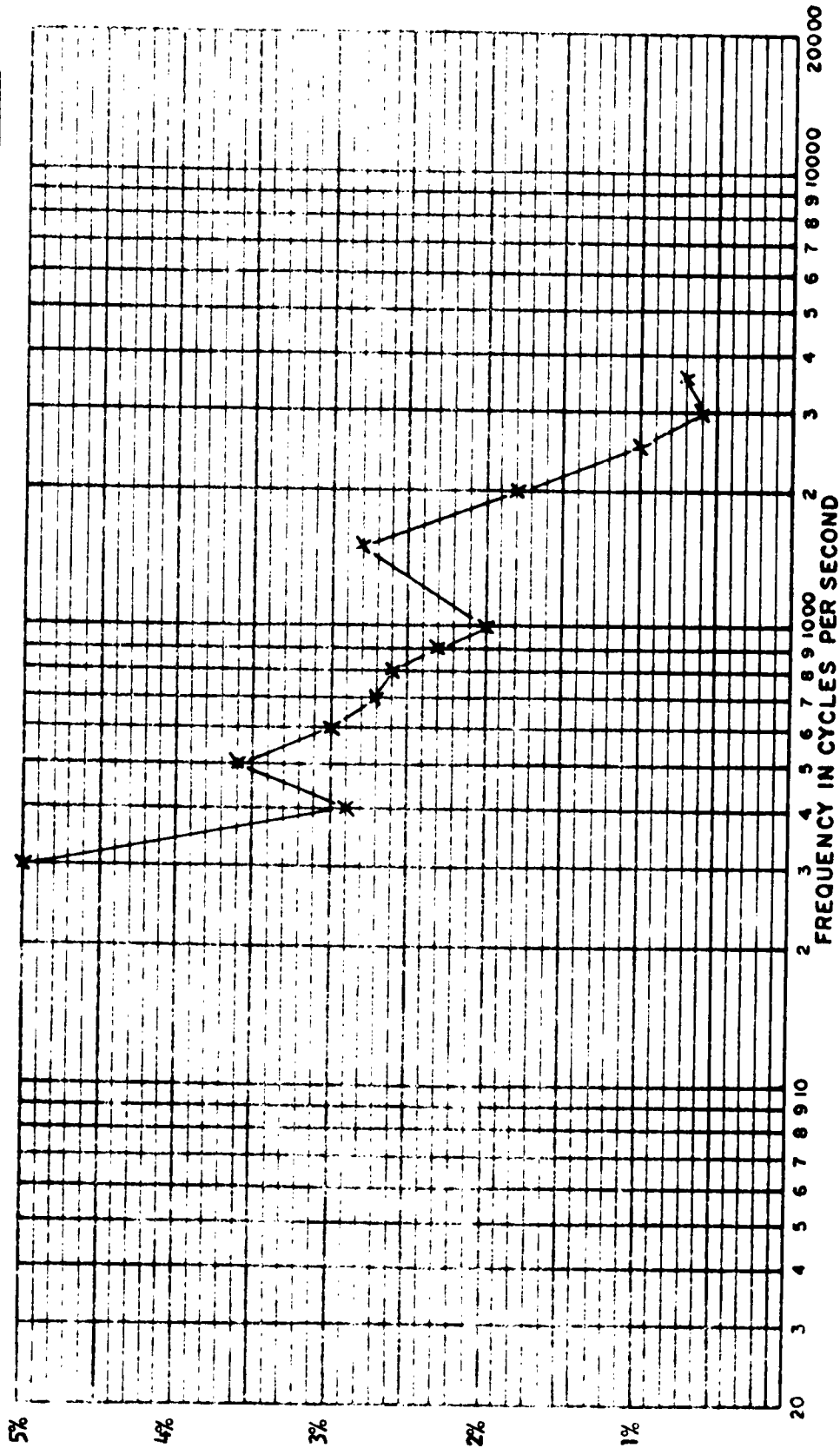
FIGURE 44.

TEST RESULTS

TEST Microphone Distortion

SPEC. REF. _____

DATE 7-5-62



COMMENTS _____

UNIT NO. 16

FIGURE 45.

TEST RESULTS

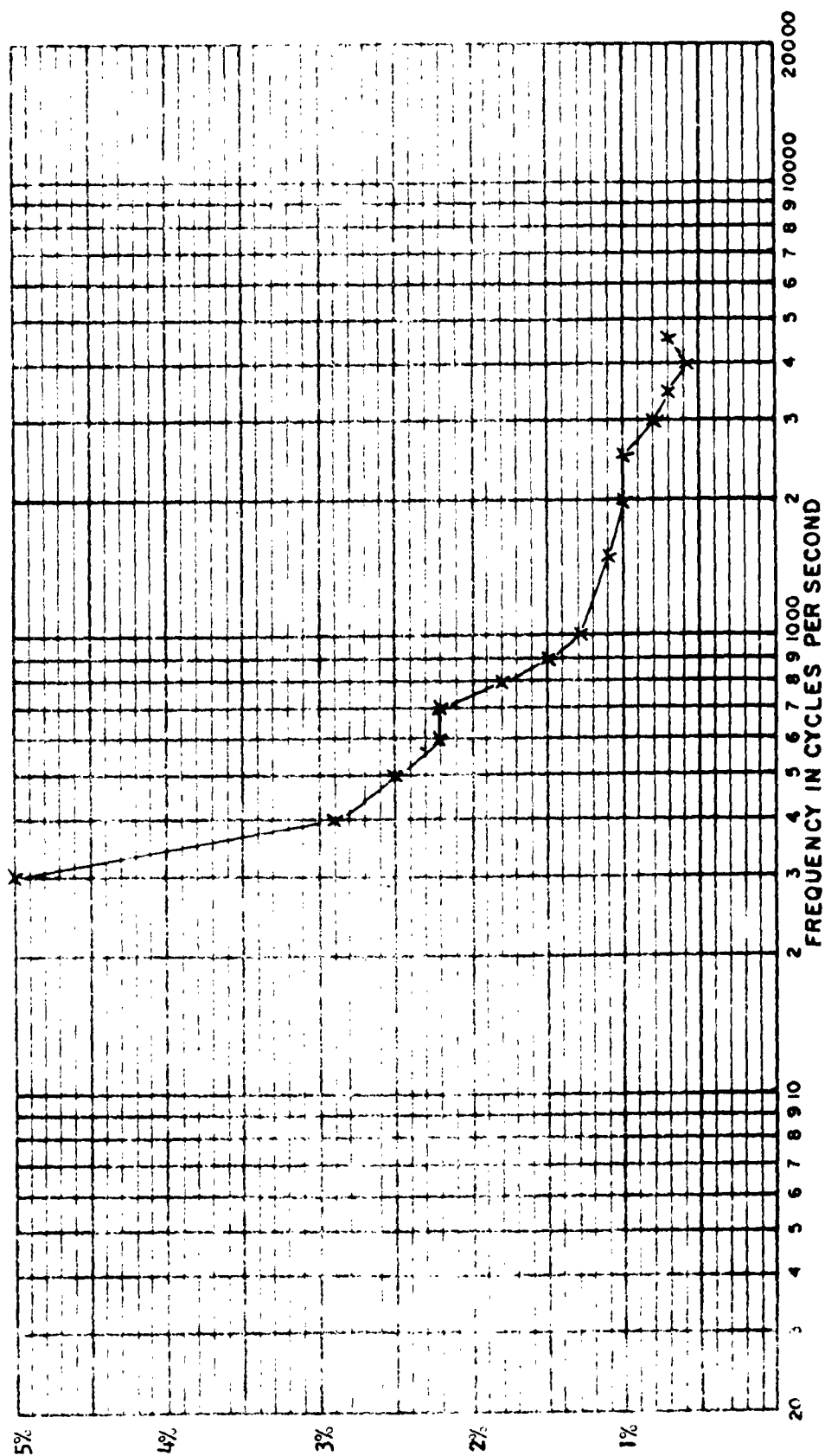
TEST Microphone Distortion

SPEC. REF.

SCL-4195

DATE 7-5-62

Par. 4.5.4



COMMENTS UNIT NO. 18

FIGURE 46.

SECTION V

CONCLUSIONS

During the design and development of the H-189()/GR, the requirements of small size and low unit cost were important objectives. These objectives had to be continually balanced against the electrical, acoustic and service condition requirements of SCL-4195; and additionally had to be balanced against the requirement for reliability. It is the opinion of the contractor that the development as concluded was successful in fulfilling the requirements of small size and low cost without sacrificing other important requirements.

The earphone, with a sensitivity exceeding 105 db re .0002 dyne/cm² for one milliwatt input, was small enough to make the controlling factor on the size of the earcap the comfort of the earpiece resting against the ear.

The size of the handle and switch was sufficiently small so that the limiting factor on size was the ability of the user to handle the unit while wearing arctic gloves.

The size of the microphone, while exceeding the minimum sensitivity requirement of -56 dbm, was controlled as much by the need for a specific placement relative to the position of the earphone as by the requirement for a specified output level. In particular, while the diameter of the microphone unit was controlled primarily by the requirement to meet a specified output level; the depth and distance from the handle was controlled by the necessity of maintaining a distance and angle between the earphone and microphone that the handset would fit normal head dimensions, and by the

necessity of providing sufficient clearance between the handle and face of the user.

An important cost reducing feature of the design is the low final assembly time required. No solder operations are required and all wiring is completed by sliding five solderless terminals on the end of the cable onto the receiving pins of the switch. The installation of only three screws is required.

The design utilizes the modular concept on all sub-assemblies. The microphone, earphone and switch elements simply drop into the handset and make pressure contact with the wire buttons in the handle inserts.

SECTION VI
RECOMMENDATIONS

The requirements of meeting the immersion test in the sealed microphone cavity and also equalizing changes in ambient pressure are very nearly incompatible in the design as completed. This incompatibility could be remedied by reducing the air cavity underneath the microphone element.

The cable and connector required for the H-189()/GR are important elements of the unit cost, and in future possible uses consideration should be given to the possible use of a straight cable and the possibility of permanently wiring the handset to the radio equipment as these actions could lower the unit cost an estimated ten to twenty percent.

SECTION VII

PERSONNEL

On the following pages are brief biographical sketches of the individuals who were active in consummating this development contract.

WAYNE BEAVERSON

Duties:

Vice President for Engineering.
In charge of the various groups
in the Engineering Department.

Education:

B.S.E.E., University of Notre Dame, 1948.

M.S.E.E., University of Notre Dame, 1949.

Experience:

Electro-Acoustical work at Electro-Voice since receiving B.S.E.E.

Accomplishments:

Worked on design and developmental problems relating to all types of microphones.

Worked on design and development of single diaphragm second-order-gradient microphone and co-author of article on the subject.

Length of Service at E-V:

Since early 1948.

Societies:

Associate member of A.S.A.

I.R.E.

Registered Professional Engineer

ROBERT RAMSEY

Duties: Chief Engineer, Microphones.
Responsible for research, design and development of microphones.

Education: B.S.E.E., Iowa State College, 1948.

Experience: Two years as Communications Officer,
U.S. Air Corps.

Four years as an Engineering Supervisor
with WOC-TV, Davenport, Iowa.

Six years of design and development at
Electro-Voice.

Accomplishments: Supervised the production of the first
2,000 12TRXB speakers.

Design of Cardiline microphones.

Design of Model 347 paging speaker.

Design of Model 513 cutoff filter.

Length of Service at E-V: Since August 1954.

Societies: I.R.E.
A.S.A.

HAROLD MOSIER

Duties: Chief Engineer, Phonograph Cartridges.
Responsible for research, design and development of phonograph cartridges.

Education: B.S.E.E. at U.S. Naval Academy and University of Michigan, 1955.

Experience: Eighteen months as electronics technician at University of Michigan. Primarily involved with high frequency amplifiers and power supplies.

Accomplishments: Partially designed and constructed a 5000 volts - 100 m.a. - 60 cycles regulated power supply.

Length of Service at E-V: Since June 1955.

Societies: I.R.E.
A.S.A.

STEPHEN HANCHAR

Duties: Project Engineer, Microphones.

Education: B.S.M.E., Purdue University, 1960.

Experience: Worked on the Industrial Co-op
Program with Bendix Products Division,
Missiles.

Length of Service at E-V: Since June 1960.

Societies: American Society of Mechanical Engineers
Purdue Alumni Society

CARL GOY

Duties: Project Engineer, Microphones.

Education: B.S.E.E., University of Notre Dame, 1961.
Ph.D., University of Paris, 1962.

Experience: Chief Engineer, WSND, Notre Dame, Indiana.

Accomplishments: Development of H-189 handset microphone.
Development of low cost commercial dynamic and ceramic microphones.

Length of Service at E-V: Since 1961.

Societies: I.R.E.

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SELRA/NP	1
SELRA/N	1
SELRA/NES	1
SELRA/NRC	1
SELRA/LNR	1
SELRA/LNF	1
Lionel Corporation Sager Place Irvington, New Jersey	1
Roanwell Corporation 75 Varick Street New York 14, New York	1
Telephonics Corporation Park Avenue Huntington, Long Island	1